Chapter 3

Summary Of North West Pacific And Northern Indian Ocean Tropical Cyclones

3.1 NORTH WEST PACIFIC OCEAN TROPICAL CYCLONES

The 1998 tropical cyclone season was notable for the shift of the cyclone genesis region west, the lack of tropical cyclone activity and the late tropical cyclone season start[1]. These events as compared to the 1997 tropical cyclone season represented a pendulum swing to the opposite. The 1997 season was noted for tropical cyclone genesis near or east of the dateline, a slight increase in the number of tropical cyclones and an early start of tropical cyclone activity.

1998 tropical cyclone genesis occurred mainly in the Philippine and South China Seas (Figure 3-1). As compared to the 15-year average, tropical cyclone formation east of the Mariana Islands was 70% less while the Philippine Sea region experienced nearly average formation. Of special note was the South China Sea, where a comparison of the 1998 formation numbers to the 15-year average indicates that double the amount of tropical cyclones formed in that region during 1998.

The 1998 calendar year total of 27 tropical cyclones (Table 3-1), which included 9 Tropical Depressions, 9 Tropical Storms and 9 Typhoons, was 4 below the long-term annual average. The 1998 tropical cyclone activity also represented the lowest annual number of tropical cyclones to occur in 10 years.

The "start" of the 1998 tropical cyclone season, as signaled by the first JTWC warning issued, commenced on 7 July 1998. This was the latest "start" of the North West Pacific Ocean tropical cyclone season ever recorded by the JTWC. Although the 1998 tropical cyclone number was relatively low, the forecast challenge presented by these cyclones was high. Of note was the forecast challenge of TY Rex (06W), whose movement and intensity were affected by a Mid-tropospheric Subtropical Ridge and a Tropical Upper Tropospheric Trough (TUTT).

3.2 NORTH INDIAN OCEAN TROPICAL CYCLONES

In 1998 eight significant tropical cyclones (Table 3-5 and Figure 3-5a and 3-5b) occurred in this region causing widespread flooding and numerous fatalities especially in Bangladesh and the Gujarat, Kutch and Saurashtra regions of India.

There was an even split between the Bay of Bengal and Arabian Sea for tropical cyclone development with the most intense tropical cyclone (TC 03A with maximum winds of 105 kt) occurring in the Arabian Sea.

TC 03A was unusual because of its record maximum and its June occurance. This cyclone developed outside the climatologically favored Spring and Fall tropical cyclone formation period expected for North Indian Ocean (Table 3-6).

[1]Unless otherwise stated, the data set used for comparison is JTWC tropical cyclone data for the period from 1959 to 1998.

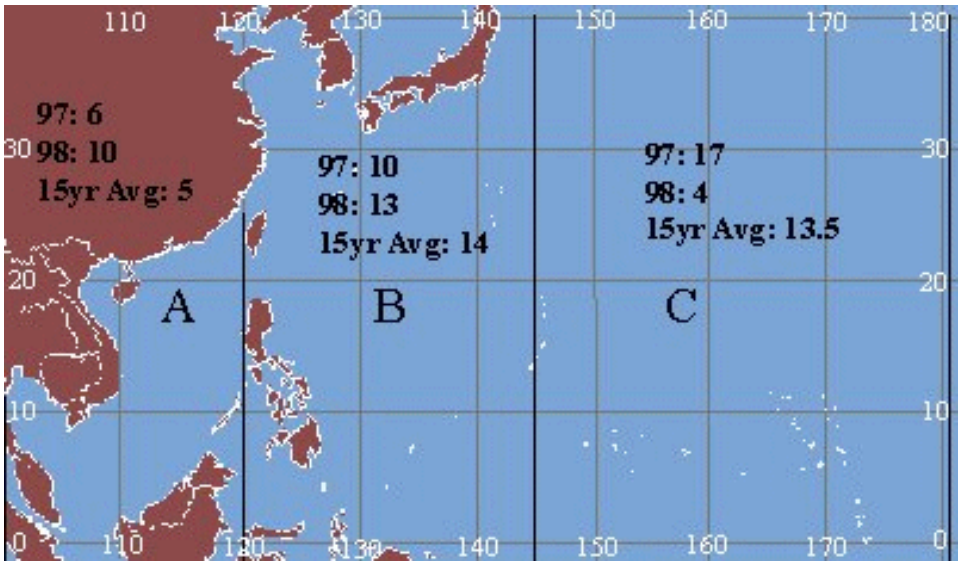


Figure 3-1. Comparison of the number of tropical cyclones that developed within 3 designated areas for 1997, 1998 and the 15-year average.

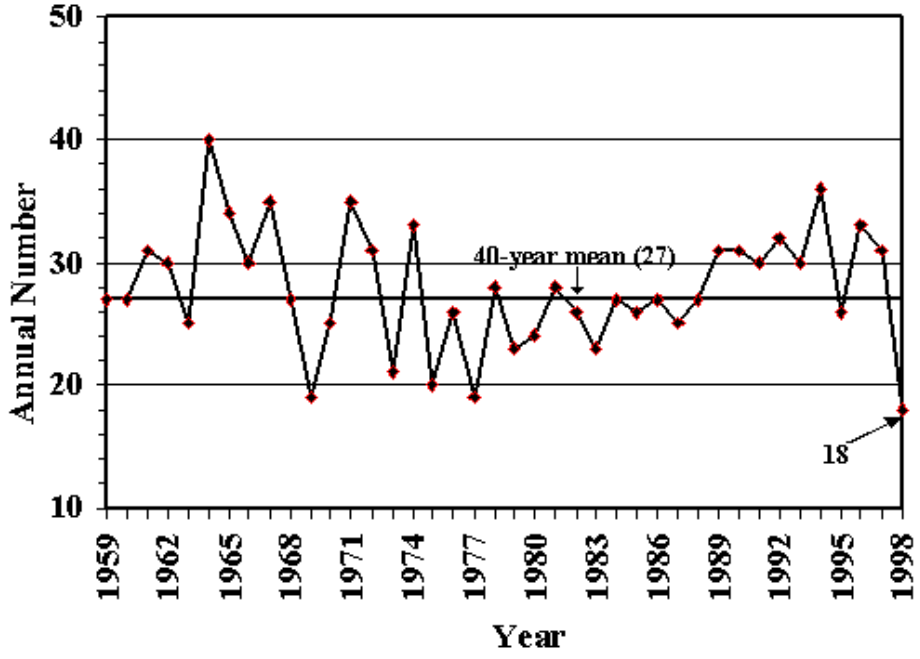


Figure 3-2. Tropical Cyclones of Tropical Storm or greater intensity in the Western North Pacific (1960-1998)

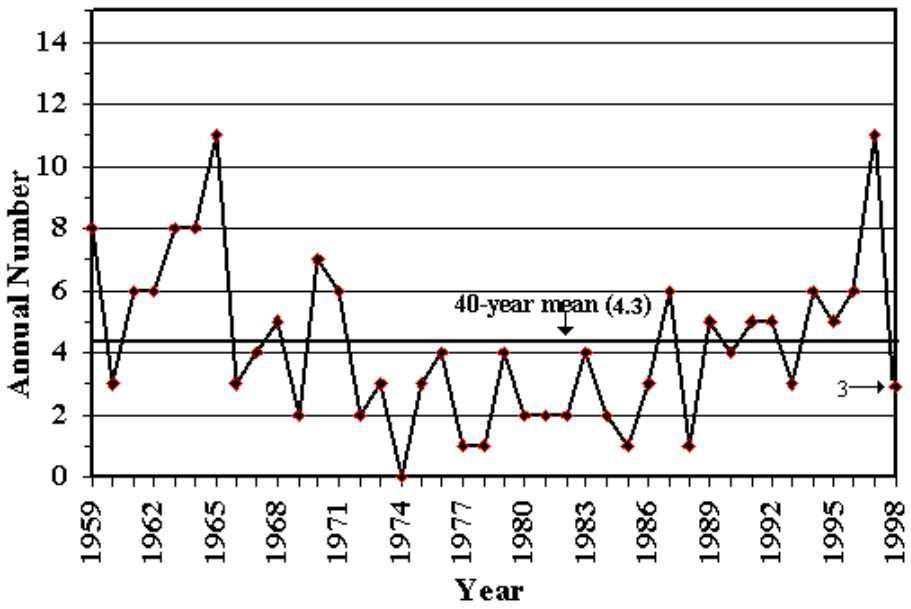


Figure 3-3. Number of Western North Pacific Super Typhoons (1960-1998)

TABLE 3-1 WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES FOR 1998

TROPICAL CYCLONE	PERIOD OF WARNING	NUMBER OF WARNINGS ISSUED	ESTIMATED MAXIMUM INTENSITY KT (M/SEC)	ESTIMATED MSLP (MB)
01W TD	07 JUL-11 JUL	15	30 (15)	1000
02W TS NICHOLE	08 JUL- 12 JUL	16	50 (26)	987
03W TS NO NAME*	25 JUL- 26 JUL	6	45 (23)	991
04W TY OTTO**	02 AUG - 05 AUG	13	100 (52)	944
05W TS PENNY	06 AUG - 11 AUG	18	60 (30)	980
06W TY REX	24 AUG - 07 SEP	57	115 (58)	927
07W TD	02 SEP - 04 SEP	9	30 (15)	1000
08W TY STELLA	12 SEP - 16 SEP	18	65 (33)	976
09W TD	13 SEP	3	25 (12)	1002
10W STY TODD***	16 SEP - 20 SEP	17	130 (67)	910
11W TY VICKI	17 SEP - 23 SEP	25	90 (46)	954
12W TD	18 SEP - 19 SEP	7	30 (15)	1000
13W TS WALDO	20 SEP - 21 SEP	9	45 (23)	991
14W TY YANNI	25 SEP - 01 OCT	26	80 (41)	963
15W TD	03 OCT - 05 OCT	11	30 (15)	1000
16W TD	05 OCT - 07 OCT	11	30 (15)	1000
17W TD	06 OCT - 07 OCT	5	30 (15)	1000

TABLE 3-1 WESTERN NORTH PACIFIC SIGNIFICANT TROPICAL CYCLONES FOR 1998

18W STY ZEB	09 OCT - 18 OCT	34	155 (80)	878
19W TS ALEX	11 OCT - 13 OCT	8	45 (23)	991
20W STY BABS	14 OCT - 27 OCT	55	135 (69)	904
21W TS CHIP	12 NOV - 15 NOV	13	50 (26)	987
22W TS DAWN	18 NOV - 20 NOV	8	45 (23)	991
23W TS ELVIS	24 NOV - 26 NOV	10	45 (23)	991
24W TY FAITH	08 DEC - 14 DEC	26	90 (46)	954
25W TS GIL	09 DEC - 13 DEC	15	35 (18)	997
26W TD	17 DEC - 19 DEC	7	25 (12)	1002
27W TD	19 DEC - 22 DEC	12	30 (15)	1000

Total Warnings Issued: 454

*TS 03W was designated a tropical storm during post analysis. Hence, no name was assigned during the lifecycle of the system.

**TY Otto was upgraded to typhoon intensity during post analysis.

***STY Otto was upgraded to super typhoon intensity during post analysis.

TABLE 3-2 DISTRIBUTION OF WESTERN NORTH PACIFIC TROPICAL CYCLONES FOR 1959 - 1998

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
1959	0	1	1	1	0	1	3	8	9	3	2	2	31
	000	010	010	100	000	001	111	512	423	210	200	200	17 7 7
1960	1	0	1	1	1	3	3	9	5	4	1	1	30
	001	000	001	100	010	210	210	810	41	400	100	100	19 8 3
1961	1	1	1	1	4	6	5	7	6	7	2	1	42
	010	010	100	010	211	114	320	313	510	322	101	100	20 11 11
1962	0	1	0	1	3	0	8	8	7	5	4	2	39
	000	010	000	100	201	000	512	701	313	311	301	020	24 6 9
1963	0	0	1	1	0	4	5	4	4	6	0	3	28
	000	000	001	100	000	310	311	301	220	510	000	210	19 6 3
1964	0	0	0	0	3	2	8	8	8	7	6	2	44
	000	000	000	000	201	200	611	350	521	331	420	101	26 13 5
1965	2	2	1	1	2	4	6	7	9	3	2	1	40
	110	020	010	100	101	310	411	322	531	201	110	010	21 13 6
1966	0	0	0	1	2	1	4	9	10	4	5	2	38
	000	000	000	100	200	100	310	531	532	112	122	101	20 10 8
1967	1	0	2	1	1	1	8	10	8	4	4	1	41
	010	000	110	100	010	100	332	343	530	211	400	010	20 15 6
1968	0	1	0	1	0	4	3	8	4	6	4	0	31
	000	001	000	100	000	202	120	341	400	510	400	000	20 7 4
1969	1	0	1	1	0	0	3	3	6	5	2	1	23
	100	000	010	100	000	000	210	210	204	410	110	010	13 6 4
1970	0	1	0	0	0	2	3	7	4	6	4	0	27
	000	100	000	000	000	110	021	421	220	321	130	000	12 12 3
1971	1	0	1	2	5	2	8	5	7	4	2	0	37
	010	000	010	200	230	200	620	311	511	310	110	000	24 11 2
1972	1	0	1	0	0	4	5	5	6	5	2	3	32
	100	000	001	000	000	220	410	320	411	410	200	210	22 8 2
1973	0	0	0	0	0	0	7	6	3	4	3	0	23

TABLE 3-2 DISTRIBUTION OF WESTERN NORTH PACIFIC TROPICAL CYCLONES FOR 1959 - 1998

	000	000	000	000	000	000	430	231	201	400	030	000	12 9 2
1974	1	0	1	1	1	4	5	7	5	4	4	2	35
	010	000	010	010	100	121	230	232	320	400	220	020	15 17 3
1975	1	0	0	1	0	0	1	6	5	6	3	2	25
	100	000	000	001	000	000	010	411	410	321	210	002	14 6 5
1976	1	1	0	2	2	2	4	4	5	0	2	2	25
	100	010	000	110	200	200	220	130	410	000	110	020	14 11 0
1977	0	0	1	0	1	1	4	2	5	4	2	1	21
	000	000	010	000	001	010	301	020	230	310	200	100	11 8 2
1978	1	0	0	1	0	3	4	8	4	7	4	0	32
	010	000	000	100	000	030	310	341	310	412	121	000	15 13 4
1979	1	0	1	1	2	0	5	4	6	3	2	3	28
	100	000	100	100	011	000	221	202	330	210	110	111	14 9 5
1980	0	0	1	1	4	1	5	3	7	4	1	1	28
	000	000	001	010	220	010	311	201	511	220	100	010	15 9 4
1981	0	0	1	1	1	2	5	8	4	2	3	2	29
	000	000	100	010	010	200	230	251	400	110	210	200	16 12 1
1982	0	0	3	0	1	3	4	5	6	4	1	1	28
	000	000	210	000	100	120	220	500	321	301	100	100	19 7 2
1983	0	0	0	0	0	1	3	6	3	5	5	2	25
	000	000	000	000	000	010	300	231	111	320	320	020	12 11 2
1984	0	0	0	0	0	2	5	7	4	8	3	1	30
	000	000	000	000	000	020	410	232	130	521	300	100	16 11 3
1985	2	0	0	0	1	3	1	7	5	5	1	2	27
	020	000	000	000	100	201	100	520	320	410	010	110	17 9 1
1986	0	1	0	1	2	2	2	5	2	5	4	3	27
	000	100	000	100	110	110	200	410	200	320	220	210	19 8 0
1987	1	0	0	1	0	2	4	4	7	2	3	1	25
	100	000	000	010	000	110	400	310	511	200	120	100	18 6 1
1988	1	0	0	0	1	3	2	5	8	4	2	1	27
	100	000	000	000	100	111	110	230	260	400	200	010	14 12 1
1989	1	0	0	1	2	2	6	8	4	6	3	2	35
	010	000	000	100	200	110	231	332	220	600	300	101	21 10 4
1990	1	0	0	1	2	4	4	5	5	5	4	1	31
	100	000	000	010	110	211	220	500	410	230	310	100	21 9 1
1991	0	0	2	1	1	1	4	8	6	3	6	0	32
	000	000	110	010	100	100	400	332	420	300	330	000	20 10 2
1992	1	1	0	0	0	3	4	8	5	6	5	0	33
	100	010	000	000	000	210	220	440	410	510	311	000	21 11 1
1993	0	0	2	2	1	2	5	8	5	6	4	3	38
	000	000	011	002	010	101	320	611	410	321	112	300	21 9 8
1994	1	0	1	0	2	2	9	9	8	7	0	2	41
	001	000	100	000	101	020	342	630	440	511	000	110	21 15 5
1995	1	0	0	0	1	2	3	7	7	8	2	3	34
	001	000	000	000	010	020	210	421	412	512	020	012	15 11 8
1996	0	1	0	2	2	0	7	10	7	5	6	3	43
	000	001	000	011	110	000	610	433	610	212	132	111	21 12 10

TABLE 3-2 DISTRIBUTION OF WESTERN NORTH PACIFIC TROPICAL CYCLONES FOR 1959 - 1998

1997	1	0	0	2	3	3	4	8	4	6	1	1	33
	010	000	000	110	120	300	310	611	310	411	100	100	23 8 2
1998	0	0	0	0	0	0	3	3	8	6	3	4	27
	000	000	000	000	000	000	012	210	413	213	030	112	9 9 9
(1959-1998)													
MEAN	0.6	0.3	0.6	0.7	1.2	2.0	4.5	6.3	5.7	4.7	2.9	1.5	30.8
CASES	22	11	23	29	48	79	178	251	227	188	116	60	1233

The criteria used in TABLE 3-2 are as follows:

1) If a tropical cyclone was first warned on during the last two days of a particular month and continued into the next month for longer than two days, then that system was attributed to the second month.

2) If a tropical cyclone was warned on prior to the last two days of a month, it was attributed to the first month, regardless of how long the system lasted.

3) If a tropical cyclone began on the last day of the month and ended on the first day of the next month, that system was attributed to the first month. However, if a tropical cyclone began on the last day of the month and continued into the next month for only two days, then it was attributed to the second month.

TABLE 3-3 WESTERN NORTH PACIFIC TROPICAL CYCLONES

TYPHOONS (1945-1959)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.3	0.1	0.3	0.4	0.7	1	2.9	3.1	3.3	2.4	2	0.9	16.4
CASES	5	1	4	6	10	15	29	46	49	36	30	14	245

TYPHOONS (1960-1998)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.3	0.1	0.2	0.4	0.7	1.1	2.8	3.5	3.5	3.3	1.7	0.7	18.3
CASES	10	2	8	16	27	41	107	134	133	126	63	27	694

TROPICAL STORMS AND TYPHOONS (1945-1959)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.4	0.1	0.5	0.5	0.8	1.6	2.9	4	4.2	3.3	2.7	1.2	22.2
CASES	6	2	7	8	11	22	44	60	64	49	41	18	332

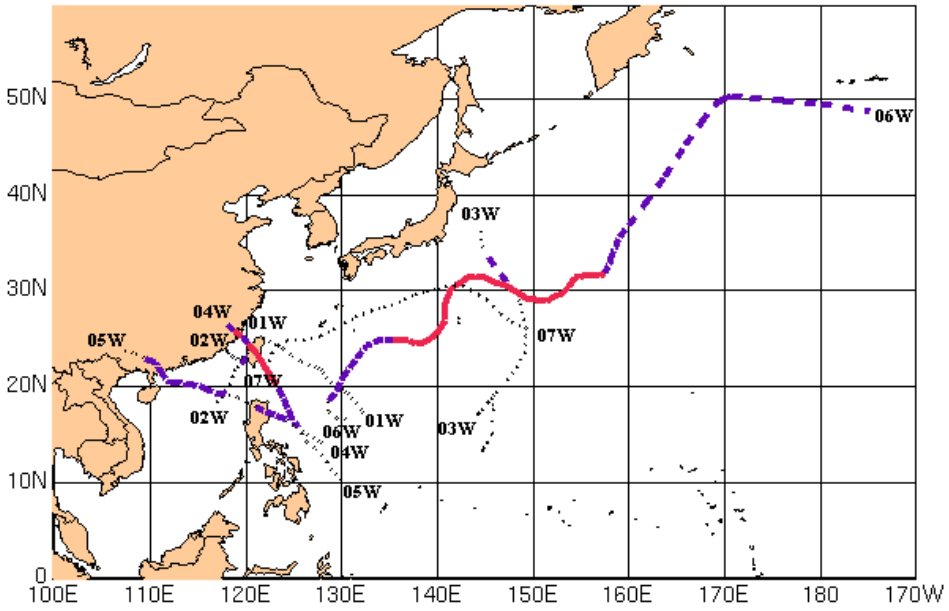
TROPICAL STORMS AND TYPHOONS (1960-1998)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
MEAN	0.5	0.2	0.4	0.7	1.2	1.8	4.3	5.7	5.2	4.4	2.7	1.3	28.5
CASES	20	9	17	25	44	70	165	218	198	167	104	49	1085

TABLE 3-4 TROPICAL CYCLONE FORMATION ALERTS FOR THE WESTERN NORTH PACIFIC OCEAN FOR 1976-1998

YEAR	INITIAL TCFAS	TROPICAL CY-CLONES WITH TCFAS	TOTAL TROP-ICAL CY-CLONES	PROBABILITY OF TCFA WITH-OUT WARNING*	PROBABILITY OF TCFA BE-FORE WARNING
1976	34	25	25	26%	100%
1977	26	20	21	23%	95%
1978	32	27	32	16%	84%
1979	27	23	28	15%	82%
1980	37	28	28	24%	100%
1981	29	28	29	3%	96%
1982	36	26	28	28%	93%
1983	31	25	25	19%	100%
1984	37	30	30	19%	100%
1985	39	26	27	33%	96%
1986	38	27	27	29%	100%
1987	31	24	25	23%	96%
1988	33	26	27	21%	96%
1989	51	32	35	37%	91%
1990	33	30	31	9%	97%
1991	37	29	31	22%	94%
1992	36	32	32	20%	100%
1993	50	35	38	30%	92%
1994	50	40	40	20%	100%
1995	54	33	35	39%	94%
1996	41	39	43	,5%	91%
1997	36	30	33	17%	91%
1998	38	18	27	53%	67%
(1976-1998) MEAN:	37	26	30	30%	87%
TOTALS:	856	653	697	697	

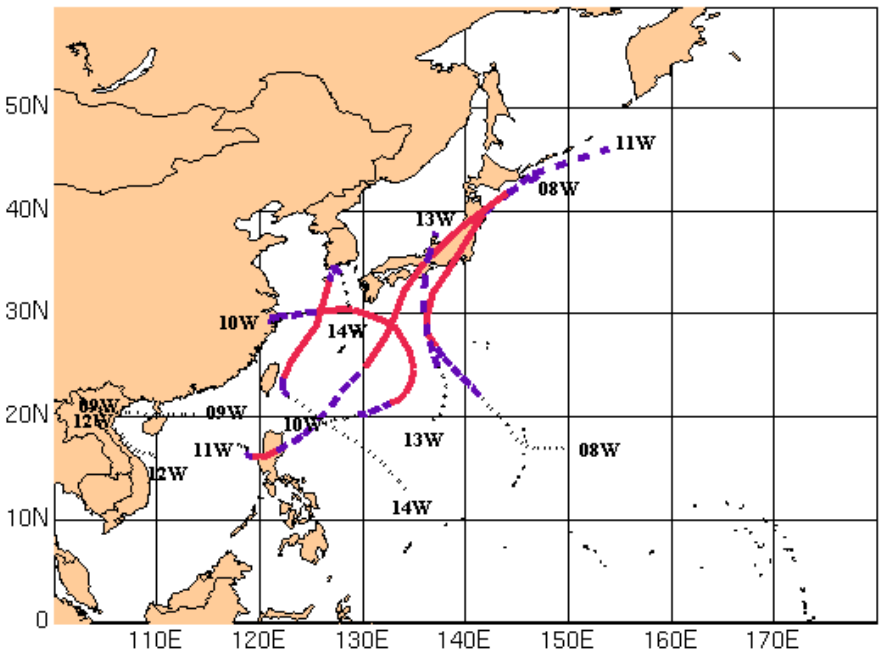
* Percentage of initial TCFA's not followed by warnings.



NORTHWEST PACIFIC OCEAN
TROPICAL CYCLONES
07 JUL 98 - 02 SEPT 98

MAXIMUM SUSTAINED SURFACE WIND
64KT (33M/SEC) OR GREATER
34 TO 63KT (18 TO 32M/SEC)
33KT (17M/SEC) OR LESS

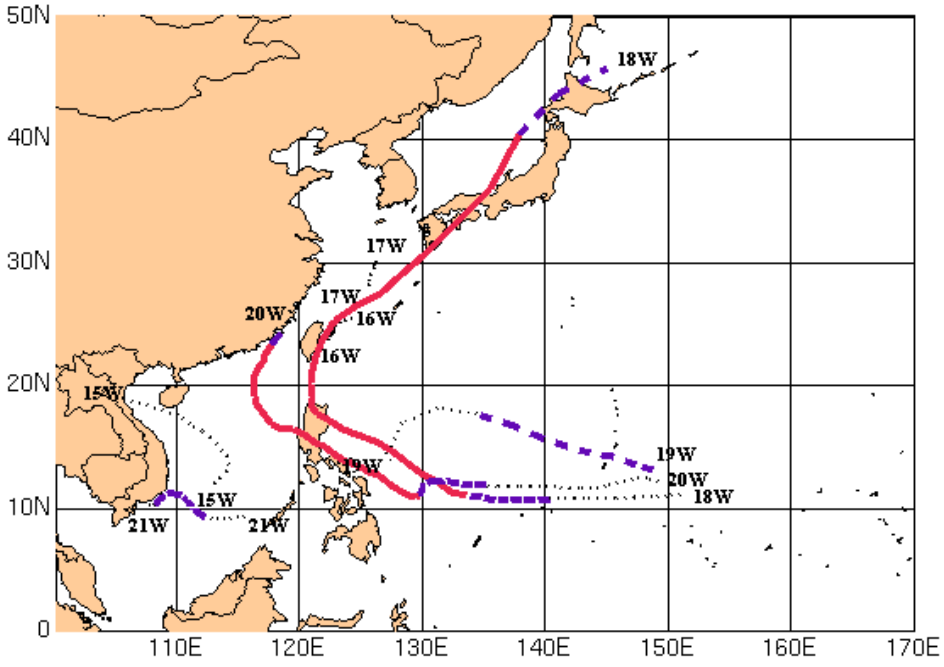
01W TD	07 JUL - 11 JUL
02W TS NICHOLE	08 JUL - 12 JUL
03W TS NO NAME	25 JUL - 26 JUL
04W TY OTTO	02 AUG - 05 AUG
05W TY PENNY	06 AUG - 11 AUG
06W TY REX	24 AUG - 07 SEPT
07W TD	02 SEPT - 04 SEPT



NORTHWEST PACIFIC OCEAN
TROPICAL CYCLONES
12 SEPT - 25 SEPT

MAXIMUM SUSTAINED SURFACE WIND
64KT (33M/SEC) OR GREATER
34 TO 63KT (18 TO 32M/SEC)
33KT (17M/SEC) OR LESS

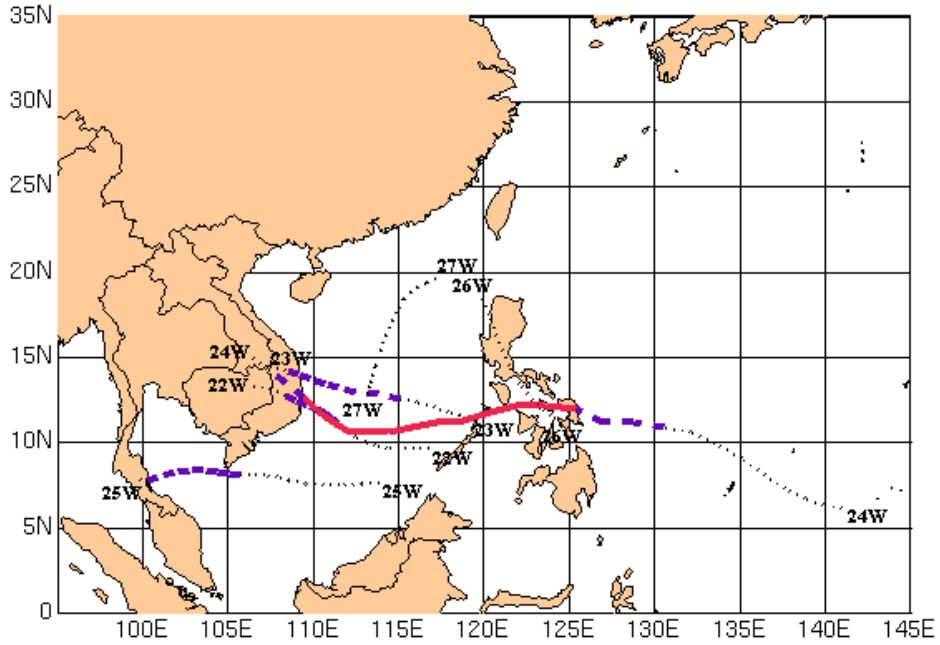
08W TY STELLA	12 SEPT - 16 SEPT
09W TD	13 SEPT - 13 SEPT
10W STY TODD	16 SEPT - 20 SEPT
11W TS VICKI	17 SEPT - 23 SEPT
12W TD	18 SEPT - 19 SEPT
13W TS WALDO	20 SEPT - 21 SEPT
14W TY YANNI	25 SEPT - 10 OCT



NORTHWEST PACIFIC OCEAN
TROPICAL CYCLONES
03 OCT 98 - 12 NOV 98

MAXIMUM SUSTAINED SURFACE WIND
64KT (33M/SEC) OR GREATER
34 TO 63KT (18 TO 32M/SEC)
33KT (17M/SEC) OR LESS

15W TD	03 OCT - 05 OCT
16W TD	05 OCT - 07 OCT
17W TD	06 OCT - 07 OCT
18W STY ZEB	09 OCT - 18 OCT
19W TS ALEX	11 OCT - 12 OCT
20W STY BABS	14 OCT - 27 OCT
21W TS CHIP	12 NOV - 15 NOV



NORTHWEST PACIFIC OCEAN
TROPICAL CYCLONES
18 NOV 98 - 19 DEC 98

MAXIMUM SUSTAINED SURFACE WIND
64KT (33M/SEC) OR GREATER
34 TO 63KT (18 TO 32M/SEC)
33KT (17M/SEC) OR LESS

22W TS DAWN	18 NOV - 20 NOV
23W TS ELVIS	24 NOV - 26 NOV
24W TY FAITH	08 DEC - 14 DEC
25W TS GIL	09 DEC - 13 DEC
26W TD	17 DEC - 19 DEC
27W TD	19 DEC - 22 DEC

TABLE 3-5 NORTH INDIAN OCEAN SIGNIFICANT TROPICAL CYCLONES FOR 1998

TROPICAL CYCLONE	PERIOD OF WARNING	NUMBERS OF WARNINGS ISSUED	ESTIMATED MAX INTENSITY KT (M/SEC)		EST MSLP (MB)
01B	18 MAY 20 MAY	11	70	(35)	972
02A	28 MAY 29 MAY	5	35	(18)	997
03A	04 JUN 09 JUN	22	105	(53)	938
04A	30 SEP 01 OCT	3	35	(18)	997
05A	16 OCT 18 OCT	5	35	(18)	997
06B	14 NOV 16 NOV	6	85	(43)	958
07B	12 NOV 23 NOV	9	75	(38)	968
08A	13 DEC 17 DEC	19	65	(33)	976
			AVG	AVG	AVG
TOTAL		80	63.13	(32)	975.38

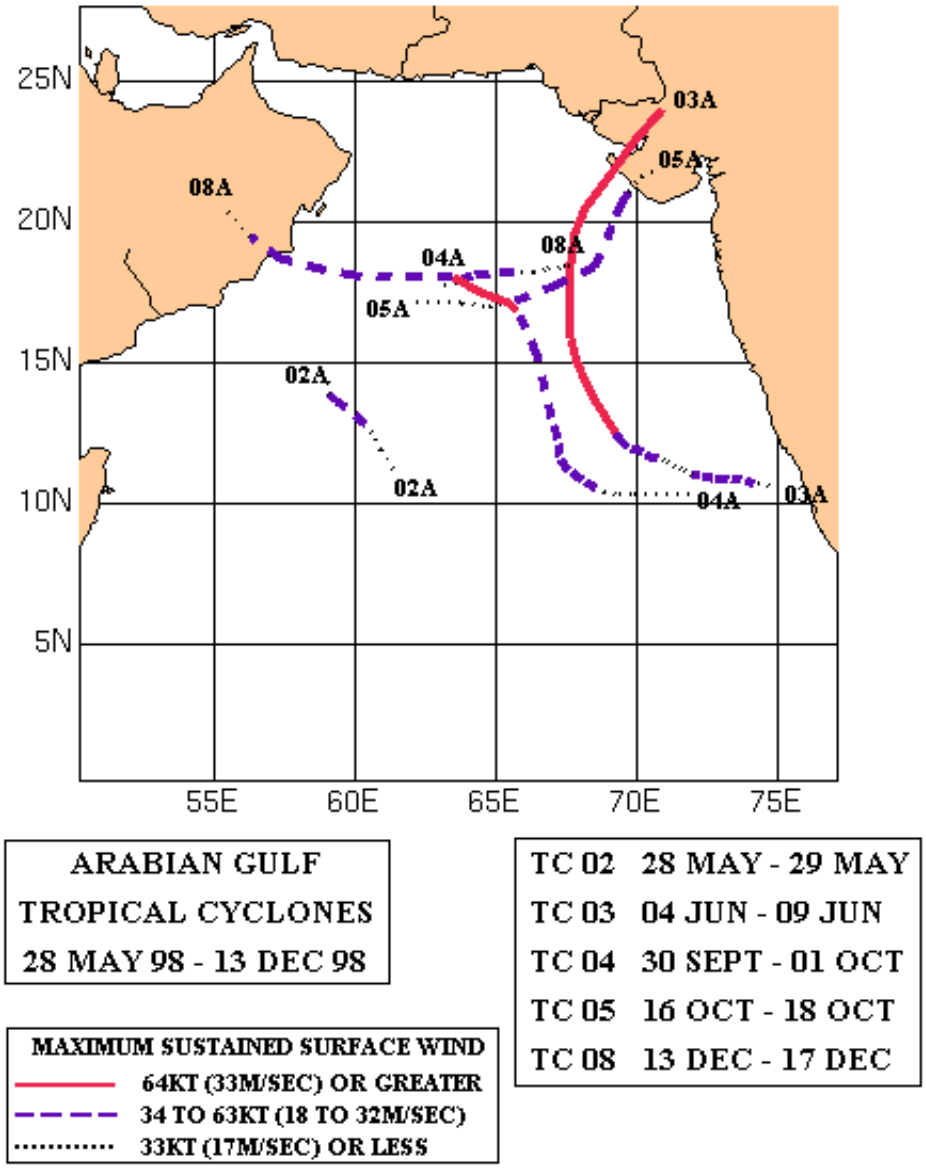
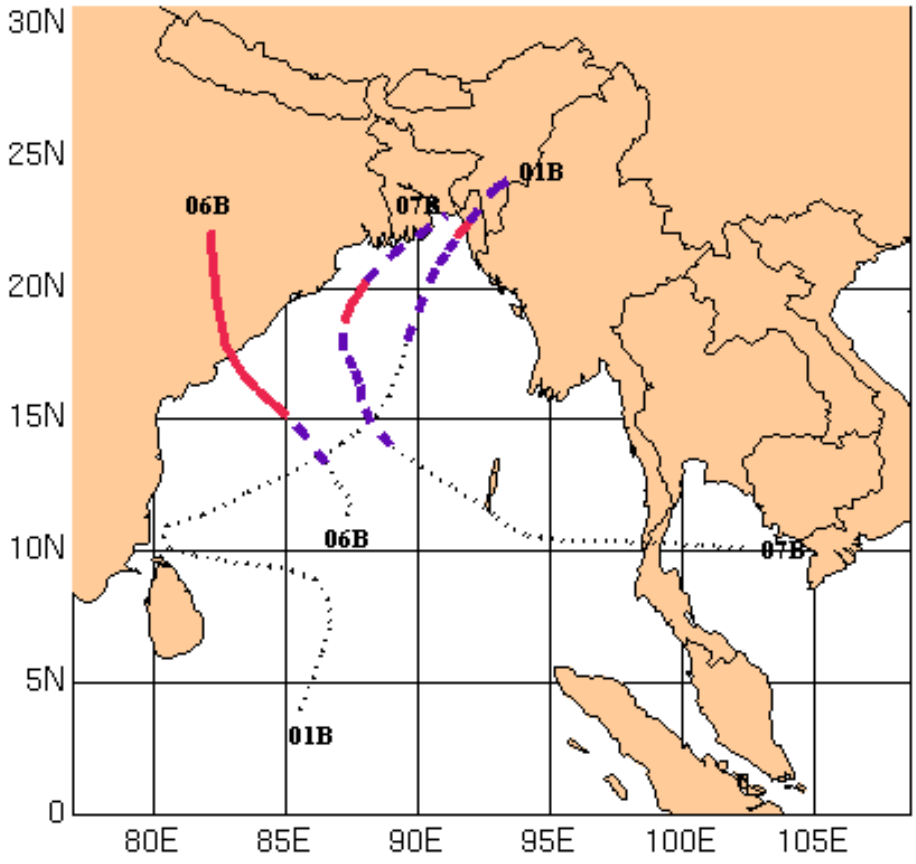


Figure 3-5a. Past data indicates annual mean genesis location of WNP tends to be east of normal during the La Nia or ENSO cold phase. Consistent with past observations for a La Nia episode, the annual mean genesis location for all TCs during 1998 was substantially north and west (Figure 3-5a) of the long term average TC genesis position. Further review of the 1998 genesis locations revealed 10 tropical cyclones developed in the South China Sea (100-120 degrees longitude), 10 in the Philippine Sea (120-145 degrees longitude), and only 4 east of Guam (145-180 degrees longitude).



BAY OF BENGAL
TROPICAL CYCLONES
18 MAY 98 - 20 NOV 98

TC 01 18 MAY - 20 MAY
TC 06 14 NOV - 16 NOV
TC 07 20 NOV - 23 NOV

MAXIMUM SUSTAINED SURFACE WIND
64KT (33M/SEC) OR GREATER
34 TO 63KT (18 TO 32M/SEC)
33KT (17M/SEC) OR LESS

TABLE 3-6 DISTRIBUTION OF NORTHERN INDIAN OCEAN TROPICAL CYCLONES FOR 1975 - 1998

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTALS
1975	1	0	0	0	2	0	0	0	0	1	2	0	6
	010	000	000	000	200	000	000	000	000	100	020	000	3 3 0
1976	0	0	0	1	0	1	0	0	1	1	0	1	5
	000	000	000	010	000	010	000	000	010	010	000	010	0 5 0
1977	0	0	0	0	1	1	0	0	0	1	0	2	5
	000	000	000	000	010	010	000	000	000	010	000	110	1 4 0
1978	0	0	0	0	1	0	0	0	0	1	2	0	4
	000	000	000	000	010	000	000	000	000	010	200	000	2 2 0
1979	0	0	0	0	1	1	0	0	2	1	2	0	7
	000	000	000	000	100	010	000	000	011	010	011	000	1 4 2
1980	0	0	0	0	0	0	0	0	0	0	1	1	2
	000	000	000	000	000	000	000	000	000	000	010	010	0 2 0
1981	0	0	0	0	0	0	0	0	1	0	1	1	3
	000	000	000	000	000	000	000	000	010	000	100	100	2 1 0
1982	0	0	0	0	1	1	0	0	0	2	1	0	5
	000	000	000	000	100	010	000	000	000	020	100	000	2 3 0
1983	0	0	0	0	0	0	0	1	0	1	1	0	3
	000	000	000	000	000	000	000	010	000	010	010	000	0 3 0
1984	0	0	0	0	1	0	0	0	0	1	2	0	4
	000	000	000	000	010	000	000	000	000	010	200	000	2 2 0
1985	0	0	0	0	2	0	0	0	0	2	1	1	6
	000	000	000	000	020	000	000	000	000	020	010	010	0 6 0
1986	1	0	0	0	0	0	0	0	0	0	2	0	3
	010	000	000	000	000	000	000	000	000	000	020	000	0 3 0
1987	0	1	0	0	0	2	0	0	0	2	1	2	8
	000	010	000	000	000	020	000	000	000	020	010	020	0 8 0
1988	0	0	0	0	0	1	0	0	0	1	2	1	5
	000	000	000	000	000	010	000	000	000	010	110	010	1 4 0
1989	0	0	0	0	1	1	0	0	0	0	1	0	3
	000	000	000	000	010	010	000	000	000	000	100	000	1 2 0
1990	0	0	0	1	1	0	0	0	0	0	1	1	4
	000	000	000	001	100	000	000	000	000	000	001	010	1 1 2
1991	1	0	0	1	0	1	0	0	0	0	1	0	4
	010	000	000	100	000	010	000	000	000	000	100	000	1 3 0
1992	0	0	0	0	1	2	1	0	1	3	3	2	13
	000	000	000	000	100	020	010	000	001	021	210	020	3 8 2
1993	0	0	0	0	0	0	0	0	0	0	2	0	2
	000	000	000	000	000	000	000	000	000	000	200	000	2 0 0
1994	0	0	1	1	0	1	0	0	0	1	1	0	5
	000	000	010	100	000	010	000	000	000	010	010	000	1 4 0
1995	0	0	0	0	0	0	0	0	1	1	2	0	4
	000	000	000	000	000	000	000	000	010	010	200	000	2 2 0
1996	0	0	0	0	1	3	0	0	0	2	2	0	8
	000	000	000	000	010	120	000	000	000	110	200	000	4 4 0
1997	0	0	0	0	1	0	0	0	1	1	1	0	4
	000	000	000	000	100	000	000	000	100	010	010	000	2 2 0

TABLE 3-6 DISTRIBUTION OF NORTHERN INDIAN OCEAN TROPICAL CYCLONES FOR 1975 - 1998

1998	0	0	0	0	2	1	0	0	1	1	2	1	8
	000	000	000	000	110	100	000	000	010	010	200	100	5 3 0
(1975-1998)													
MEAN	0.1	0.1	0.1	0.2	0.6	0.6	0.1	0.1	0.3	0.9	1.4	0.6	5
													1.5 3.3 .3
CASES	3	0	0	4	14	13	1	1	8	24	32	13	121
													36 79 6

The criteria used in TABLE 3-6 are as follows:

1) If a tropical cyclone was first warned on during the last two days of a particular month and continued into the next month for longer than two days, then that system was attributed to the second month.

2) If a tropical cyclone was warned on prior to the last two days of a month, it was attributed to the first month, regardless of how long the system lasted.

3) If a tropical cyclone began on the last day of the month and ended on the first day of the next month, that system was attributed to the first month. However, if a tropical cyclone began on the last day of the month and continued into the next month for only two days, then it was attributed to the second month.

Tropical Depression 01W

The first 1998 Northwest Pacific Ocean tropical cyclone warned on by JTWC developed in the Philippine Sea. It intensified slowly, moved northwestward, then dissipated over Taiwan after 5 days.

Tropical Depression (TD) 01W formed approximately 600 nm east of Luzon. JTWC issued the first warning on TD 01W at 071500Z July. By 080600Z July, the cyclone had reached a maximum intensity of 30 kt. Subsequently, vertical wind shear resulted in TD 01W becoming an exposed low level circulation after 090000Z July.

TD 01W moved very slowly for the initial 48 hours, then began to accelerate northwestward on the 9th to about 11 kt just before striking the northern tip of Taiwan around 102100Z July. After landfall, the cyclone dissipated quickly. The final JTWC warning was issued at 110300Z July.

The primary significance of this cyclone was that it was the latest "start" of the Northwest Pacific Ocean tropical cyclone season as indicated by JTWC records (since 1959). This late season start appears to be directly related to the "La Nia" event of 1998.

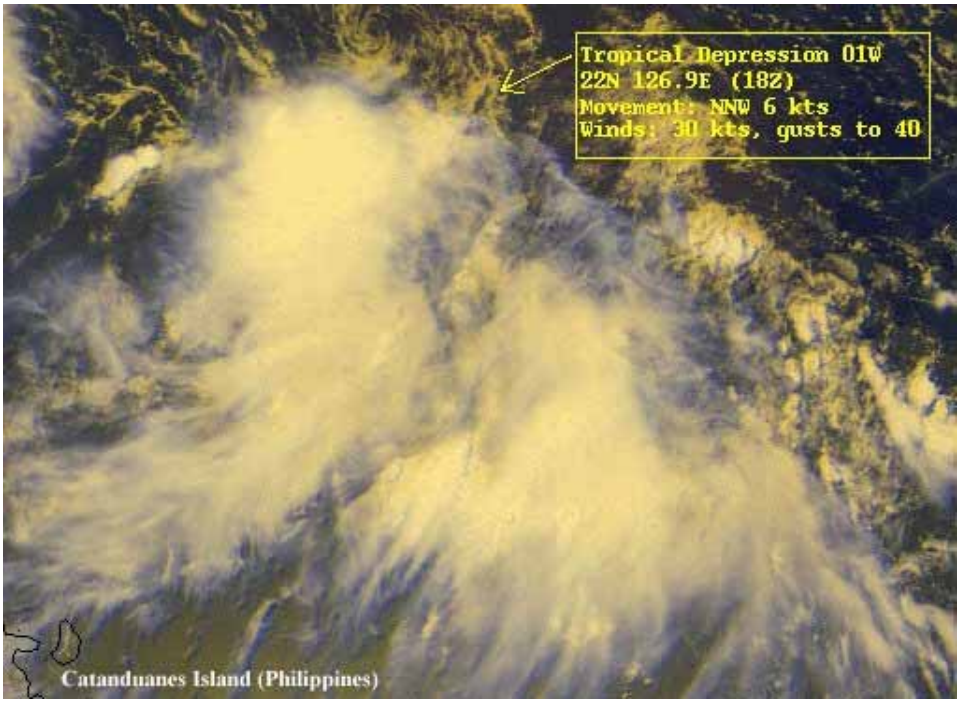
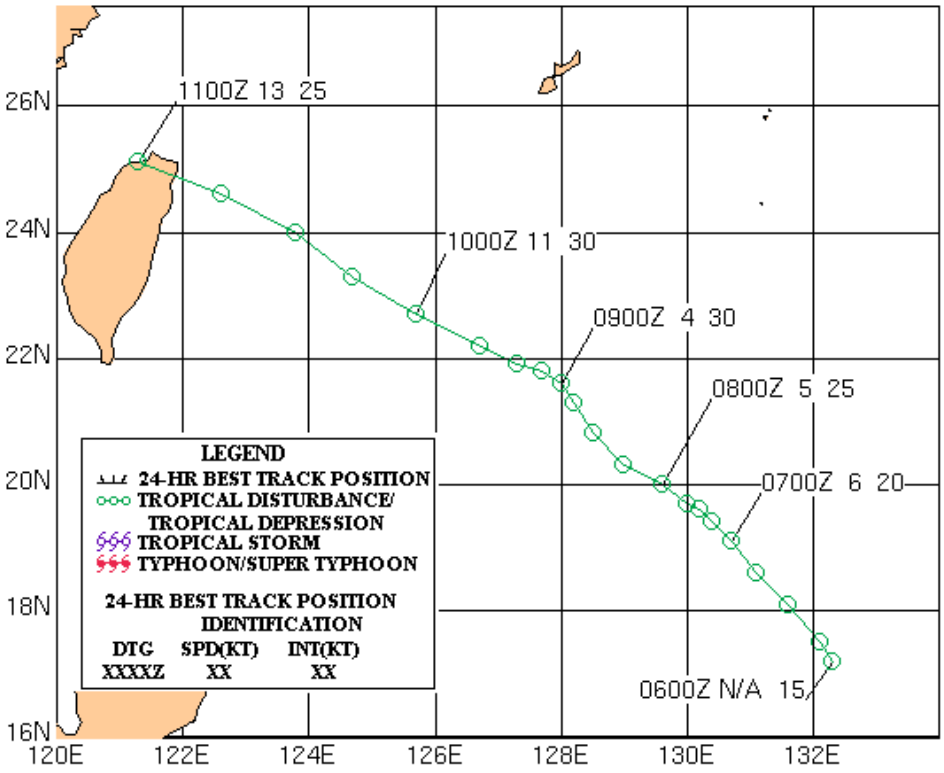


Figure 3-01-1. A NOAA multi-spectral image showing TD 01W as an exposed low-level circulation northeast of the Philippines.


1100Z 13 25
1000Z 11 30
0900Z 4 30
0800Z 5 25
0700Z 6 20
0600Z N/A 15
26N
24N
22N
20N
18N
16N
120E
122E
124E
126E
128E
130E
132E
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Tropical Storm Nichole (02W)

Tropical Storm (TS) Nichole (02W), was the second tropical cyclone and the first named storm of 1998. This cyclone formed in the South China Sea and reached a maximum intensity of 50 kt in the Taiwan Strait before making landfall and dissipating near Xiamen, China on the 12th of July.

JTWC issued a Tropical Cyclone Formation Alert at 071700Z July on a broad area of convection in the South China Sea. The first warning was issued at 080300Z July as a 25 kt cyclone. Subsequently, TS Nichole moved steadily north-northeastward at 6 to 8 kt. Due to constricted upper-level outflow to the north, it intensified slowly reaching tropical storm intensity at 081800Z July. TS Nichole achieved maximum intensity of 50 kt at approximately 091200Z July while just offshore of the southwest coast of Taiwan. Interaction with land and associated dry air entrainment, together with increased vertical shear, weakened the cyclone rapidly and TS Nichole became an exposed low level circulation. It moved westward and dissipated over southeastern China. The final warning was issued at 122100Z July.

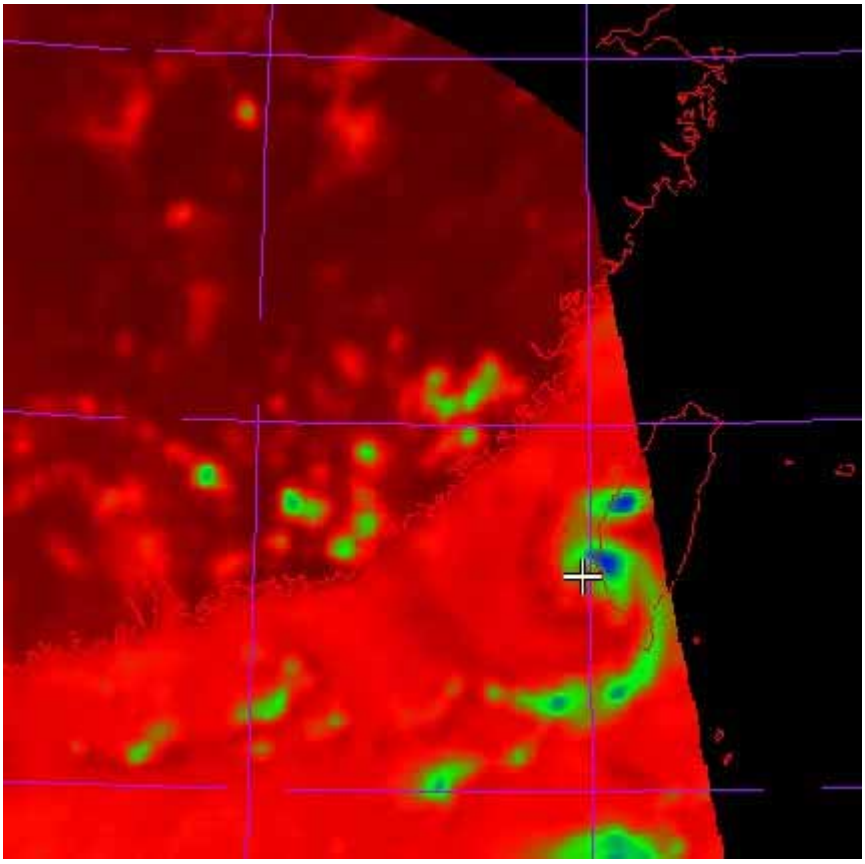
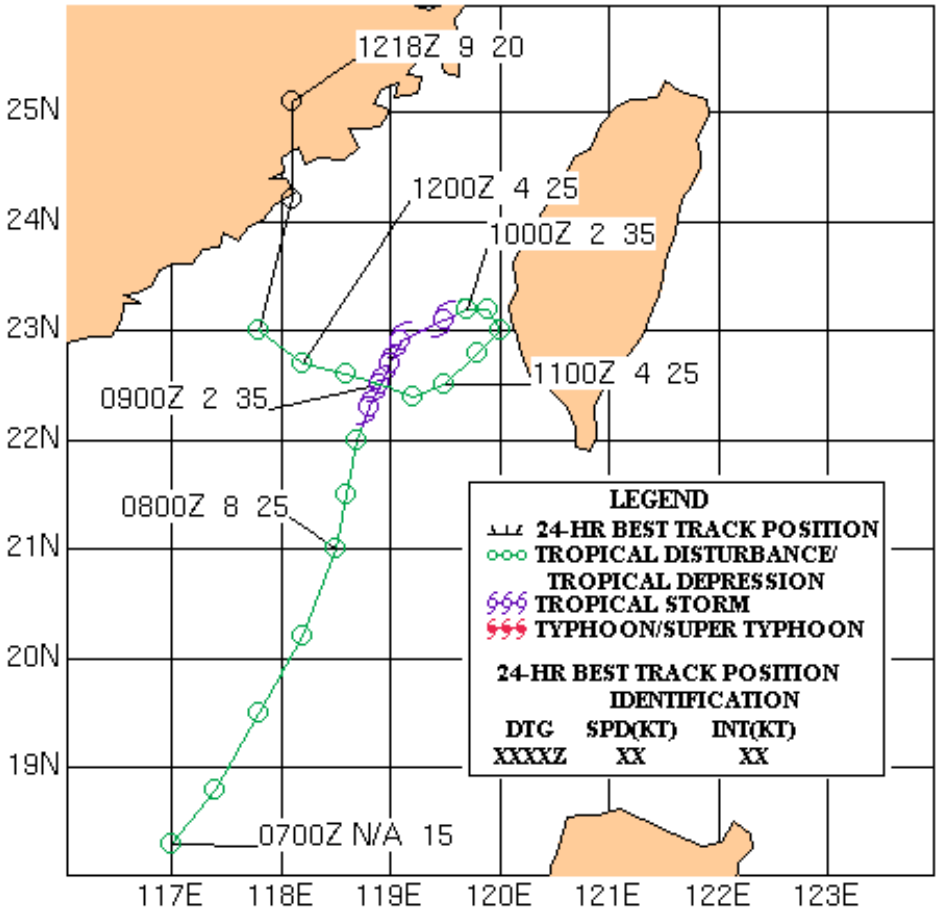


Figure 3-02-1. 090942Z July Special Sensor Microwave Imagery (SSM/I) depiction of TS Nichole at its maaximum intensity of 50 kt.


1218Z 9 20
1200Z 4 25
1000Z 2 35
1100Z 4 25
0900Z 2 35
0800Z 8 25
0700Z N/A 15
25N
24N
23N
22N
21N
20N
19N
117E
118E
119E
120E
121E
122E
123E
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Tropical Storm 03W

Tropical Storm (TS) 03W developed on the eastern periphery of a monsoon gyre 425 nm east-northeast of Iwo Jima on 25 July. Although JTWC never upgraded this cyclone to a tropical storm, post-analysis indicated a peak intensity of 45 kt. Hence, "No Name" was assigned.

JTWC first mentioned this disturbance on the 240600Z July Significant Tropical Weather Advisory (ABPW). No Tropical Cyclone Formation Alert was issued and JTWC issued the first warning at 250300Z July.

TS 03W moved cyclonically around the monsoon gyre for the first 24 hours, and intensified to 45 kt at 251200Z. As TS 03W tracked further north, it weakened as it encountered increased vertical windshear associated with the mid-latitude westerlies. TS 03W then turned northward and accelerated under the steering influence of the subtropical ridge to the southeast.

By 260533Z, vertical windshear had exposed the Low-Level Circulation Center. The final warning was issued at 260900Z July.

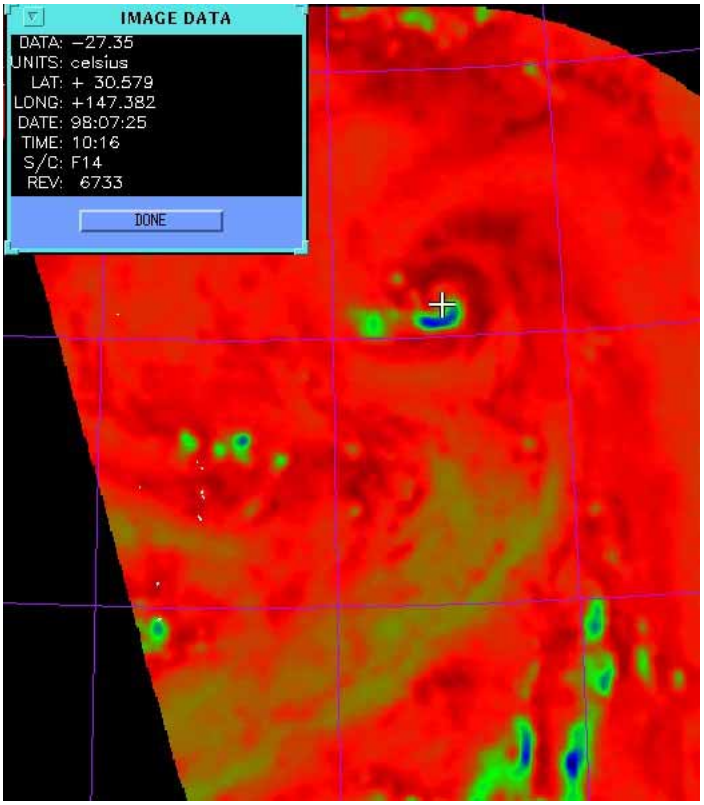


Figure 3-03-1. 25 Jul 98 1016Z SSM/I data which indicates convection wrapping into northeastern quadrant of the cyclone that supports a maximum intensity of 45 kt.

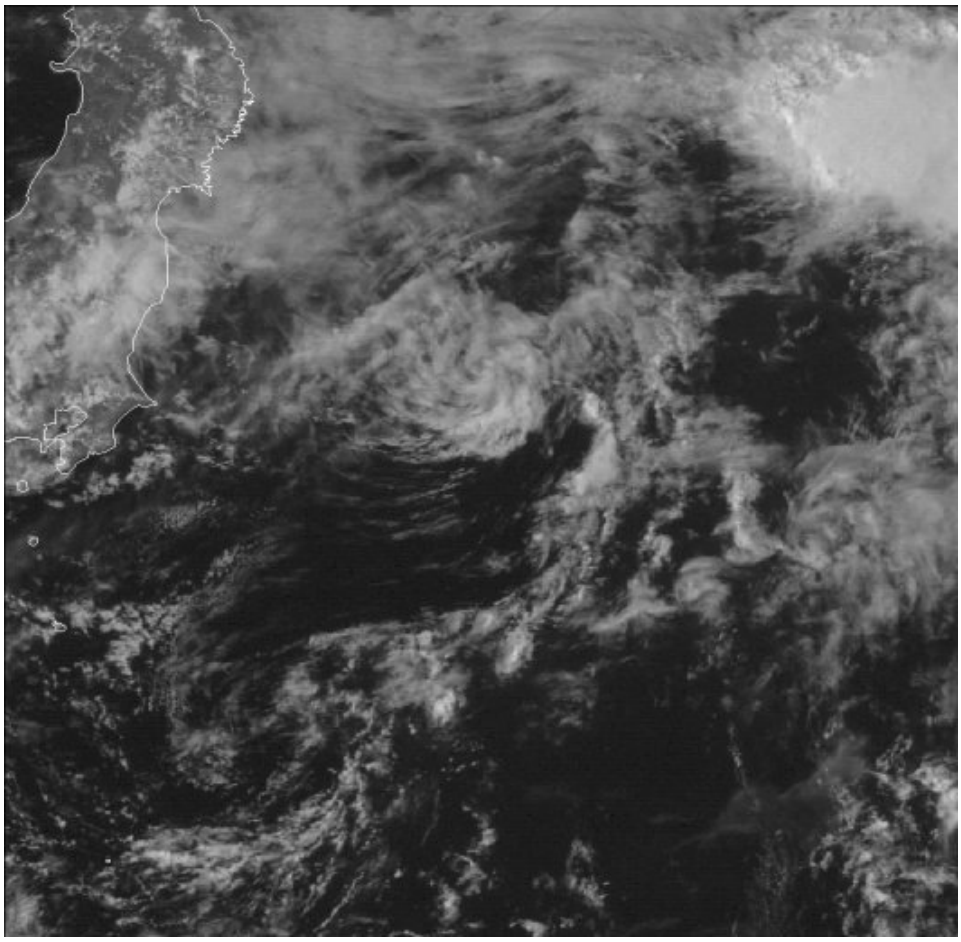
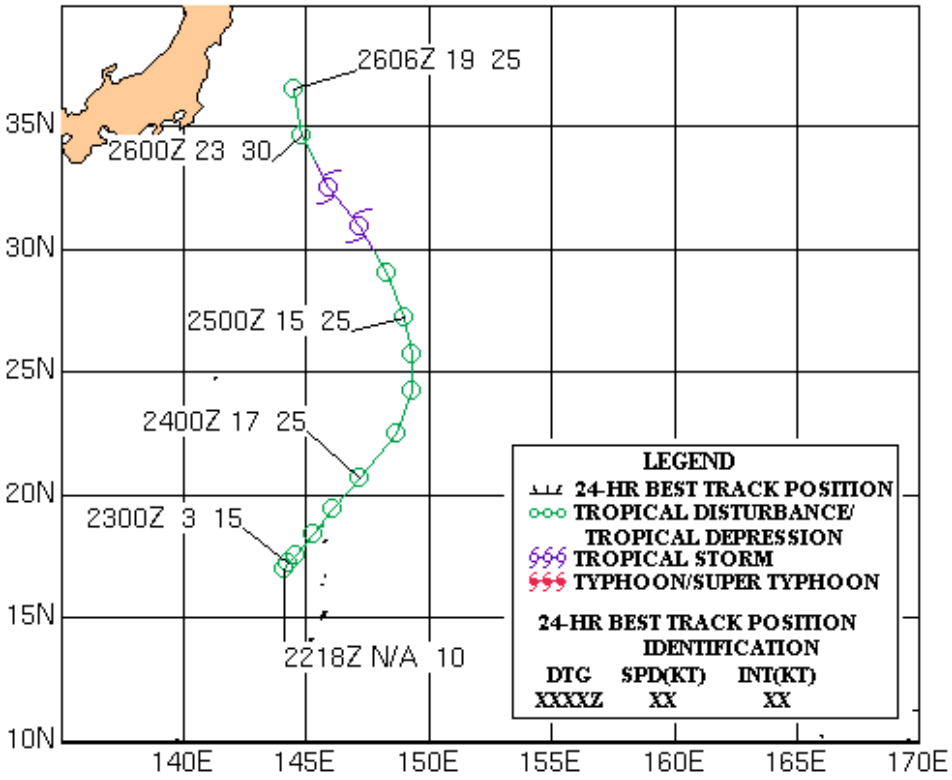


Figure 3-03-2. 260533Z July visible GMS image with TS 03W as an exposed LLCC.


2606Z 19 25
2600Z 23 30
2500Z 15 25
2400Z 17 25
2300Z 3 15
2218Z N/A 10
35N
30N
25N
20N
15N
10N
140E
145E
150E
155E
160E
165E
170E
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Typhoon Otto (04W)

Typhoon (TY) Otto (04W) formed over extremely warm ocean temperatures (¿ 30 degrees C) east of Luzon. This cyclone developed from a persistent mesoscale convective complex to a 100 kt typhoon during its relatively straight 4-day northwestward track. TY Otto tracked across Taiwan, then moved into southeastern China causing widespread flooding in Fukien Province.

Based on 011411Z August ERS-2 satellite scatterometer data and satellite imagery showing increased deep convection, JTWC issued the first warning at 020300Z August. Intensification to tropical storm occurred twelve hours later as the cyclone began to accelerate and move northwestward toward Taiwan in response to steering flow from the mid-tropospheric subtropical ridge. Minimal typhoon intensity was reached at 031200Z August.

TY Otto reached a maximum intensity of 100 kt on 040000Z August just prior to making landfall on the southeastern coast of Taiwan. The island's rugged, mountainous terrain temporarily lowered the cyclone's maximum sustained winds to 60 kt, but TY Otto reintensified to minimal typhoon intensity over the Taiwan Strait and continued to move northwestward. It then made a second landfall near the city of Fuzhou in southeastern China at 042000Z August, where the associated heavy rainfall contributed to widespread flooding in Fukien Province. Maximum sustained winds were estimated at 50 kt when JTWC issued its thirteenth and final warning at 050300Z August 1998.

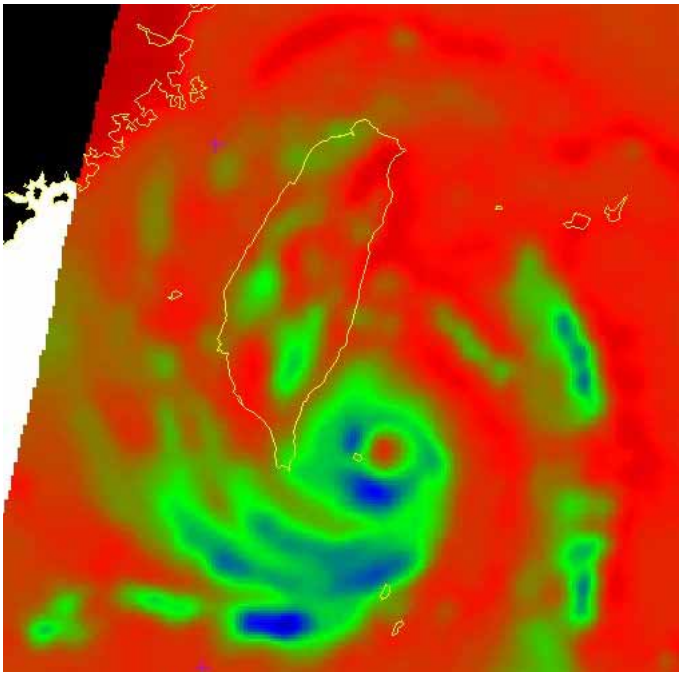


Figure 3-04-1. DMSP 040044Z August microwave image of Typhoon Otto just prior to landfall in southeastern Taiwan.

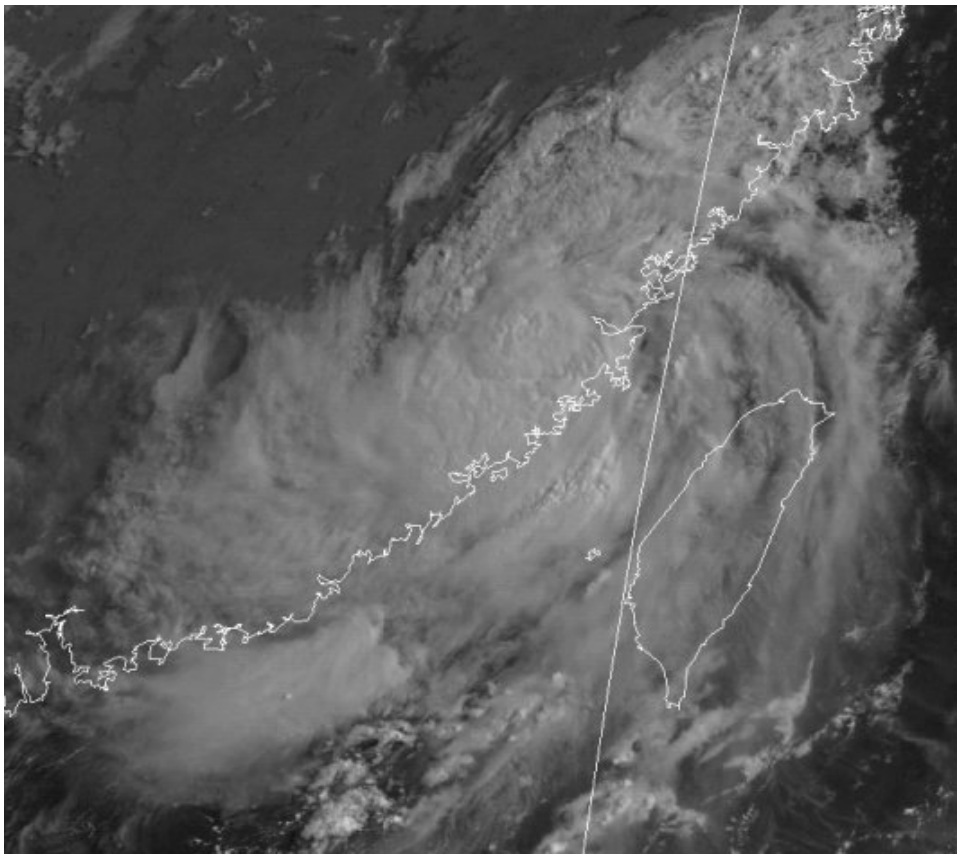
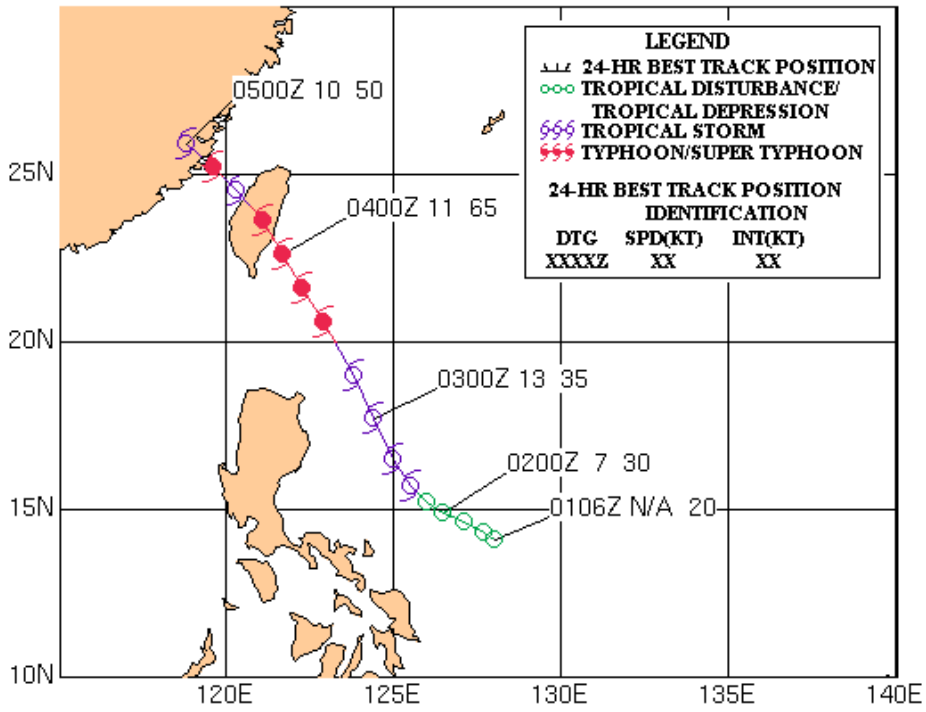


Figure 3-04-2. 050000Z August GMS-5 visible image of Typhoon Otto just after making landfall in southeastern China.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
0500Z 10 50
0400Z 11 65
0300Z 13 35
0200Z 7 30
0106Z N/A 20
25N
20N
15N
10N
120E
125E
130E
135E
140E

Tropical Storm Penny (05W)

Tropical Storm (TS) Penny (05W) formed in early August from a persistent mesoscale convective complex over the very warm Philippine Sea in the same manner as TY Otto (04W) the week prior. JTWC issued a Tropical Cyclone Formation Alert on 051900Z August as deep convection persisted and a surface cyclone began to develop. JTWC issued its first warning on TS Penny at 060900Z August with maximum sustained winds of 25 kt.

As with TY Otto (04W), the midtropospheric subtropical ridge was the primary steering influence for TS Penny (05W) during the cyclone's northwestward movement toward Luzon Island and subsequent passage across the South China Sea and into southern China.

It took 36 hours for the tropical depression to reach tropical storm intensity. This intensification occurred at 071200Z August, just prior to the cyclone making landfall over northern Luzon. Interaction with mountainous terrain temporarily weakened TS Penny to tropical depression strength but, after 18 hours, the cyclone reintensified to tropical storm strength and reached a maximum intensity of 60 kt during its South China Sea passage.

TS Penny made a second landfall in southern China near Zhanjiang at approximately 110000Z August, where associated heavy rainfall contributed to widespread flooding. Maximum sustained winds were estimated at 35 kt when JTWC issued its eighteenth and final warning at 110900Z August.

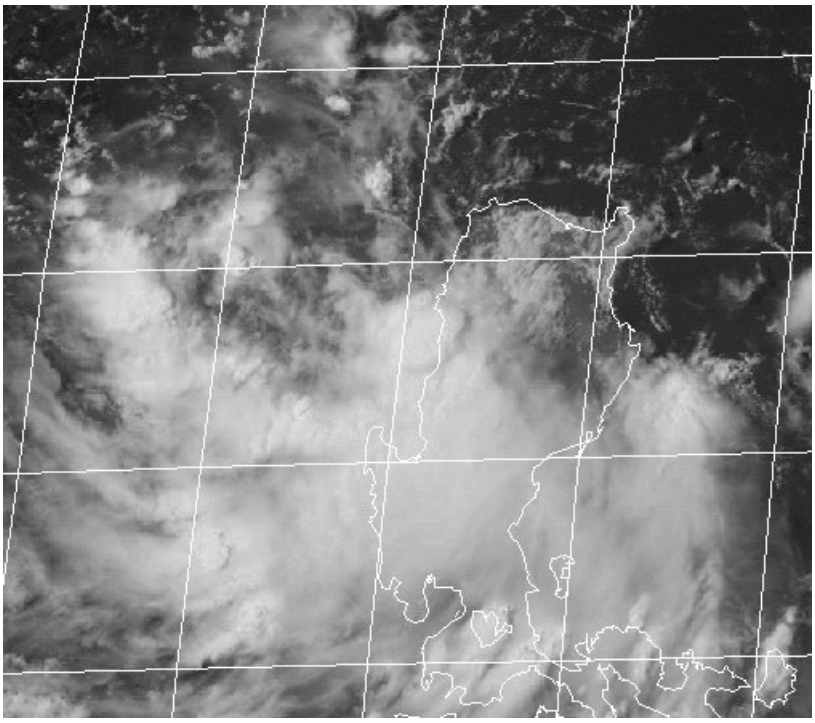


Figure 3-05-1. 080700Z August GMS-5 visible image of TS Penny crossing Luzon.

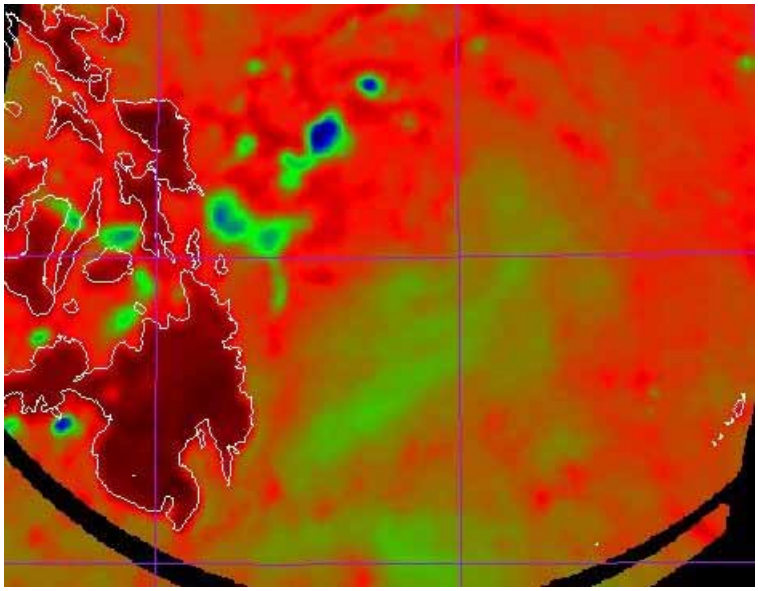
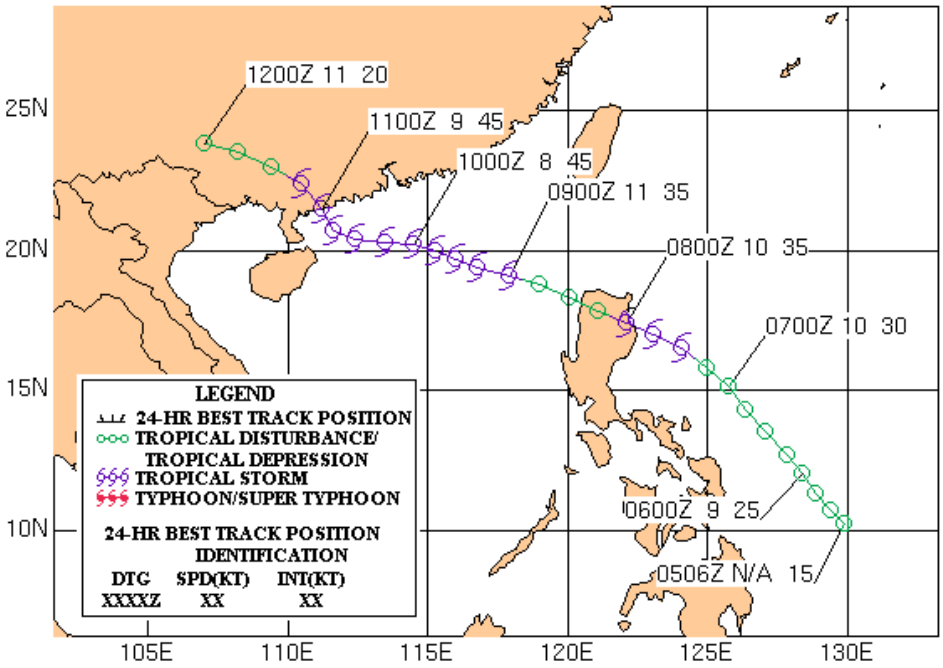


Figure 3-05-2. 060019Z August DMSP microwaveimage of TS Penny during its formative stages.



Typhoon Rex (06W)

The paramount forecasting challenge of the 1998 Northwest Pacific tropical cyclone season was Typhoon (TY) Rex (06W). This cyclone formed in the Philippine Sea and was influenced by synoptic features present in the mid and upper troposphere during its meander northeastward. The influence of 3 distinct TUTT cells caused TY Rex's track to deviate from its forecasted northeast track 3 separate times. Seventeen days after initial detection, TY Rex (06W) transitioned to an extratropical cyclone southeast of the Kamchatka Peninsula.

TY Rex (06W) formed in a broad trough east of Luzon late in August, 1998 and was first described as a suspect area on the 210600Z August JTWC Significant Tropical Weather Advisory. The first warning was issued at 240300Z August. The cyclone continued to steadily intensify as it tracked northeastward at 8 kt in response to flow emanating from the mid-tropospheric subtropical ridge to the east. On 260000Z August, TY Rex was designated a typhoon with a maximum intensity of 70 kt with an associated eastward track change noted at around the same time.

The Tropical Upper Tropospheric Trough (TUTT) was very active in August and "cells" or cyclones within this trough affected the track and intensity of Typhoon Rex. The first TUTT cell weakened the subtropical ridge to the east, allowing TY Rex to track eastward from 251200Z to 270000Z August. As the influence of the TUTT cell waned, TY Rex resumed a more northward course and reached peak intensity of 115 kt with a 30 nm diameter eye at 280600Z August. TY Rex began to move northward toward Honshu when a second, much deeper TUTT cell began to weaken the subtropical ridge to the east. In response, TY Rex again began to move east-southeastward around 310600Z August. During this period, TY Rex weakened to 90 kt and later intensified to a 100 kt cyclone at 010000Z September.

After the second TUTT cell began to move westward, TY Rex resumed its northeastward track on 020600Z September. After passing, north of 30 degrees north, TY Rex began weakening due to cooler surface waters and increased vertical wind shear. Around 031200Z September, a third TUTT cell began to interact with TY Rex, causing an eastward jaunt for approximately 18 hours. This TUTT cell, however, was the weakest of the three and rapidly collapsed, allowing Rex to resume its northeastward movement by 041200Z September.

Between 4th and 7th of September, Typhoon Rex continued to track northeastward and then eastward while transitioning into an extratropical system. JTWC issued the final warning on this cyclone at 070300Z September.

Although Rex never made landfall, its proximity to Honshu, Japan caused heavy flooding and 575 mudslides. The media reported 13 fatalities, 30 injuries, and 8,000 homes destroyed.

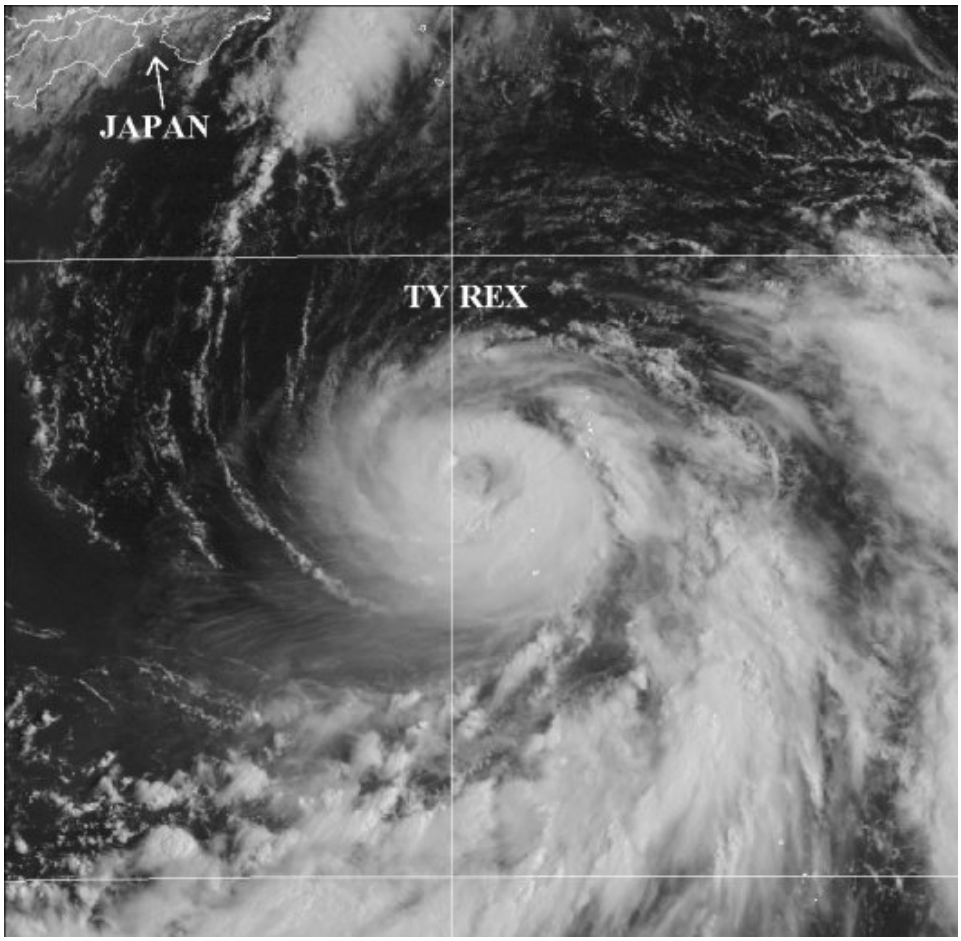


Figure 3-06-1. Visible satellite data of TY Rex at 272334Z August, 1998 when the cyclone was a 110 kt system and about 6 hours away from peak intensity of 115 kt.

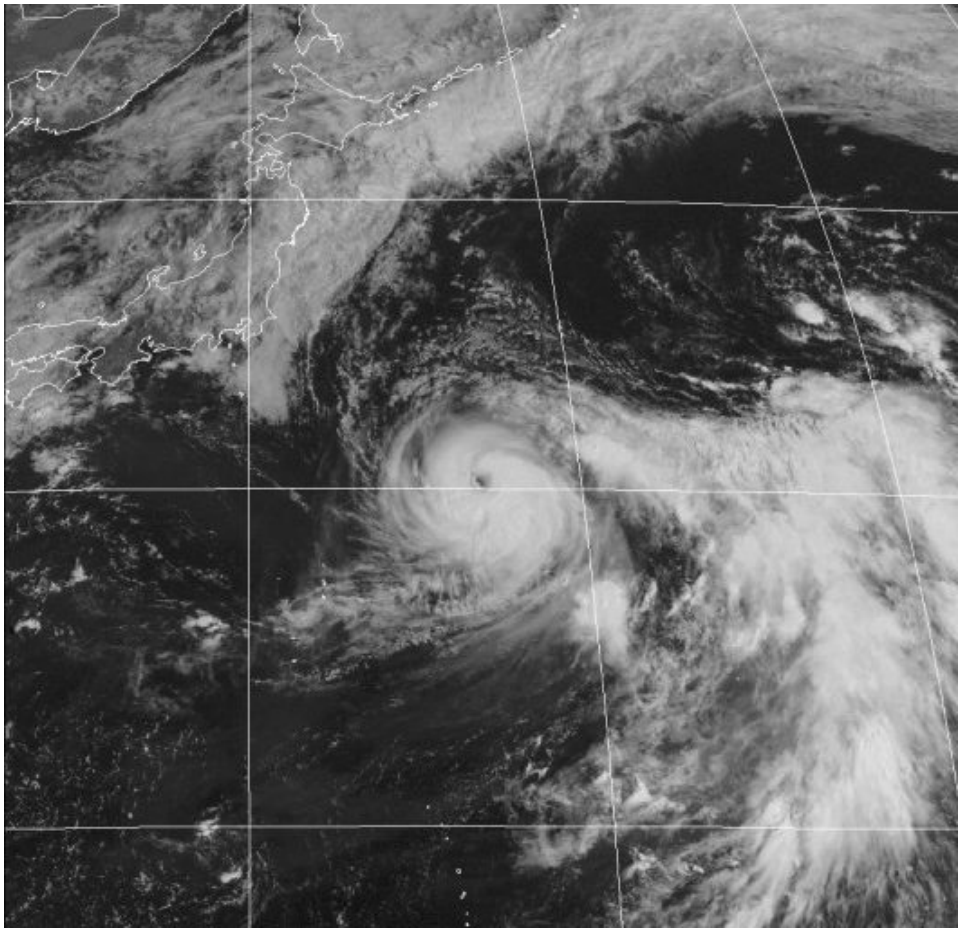
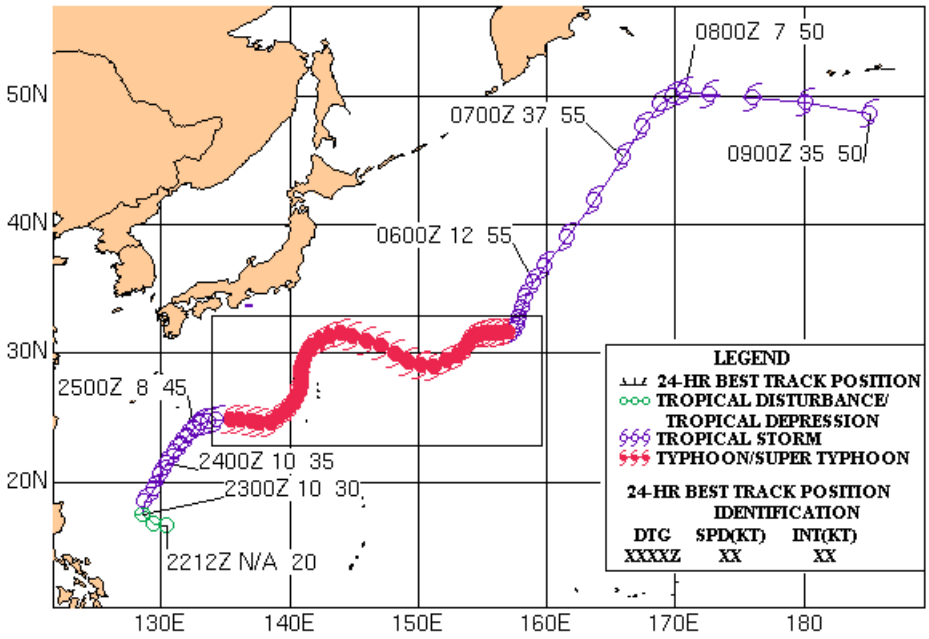
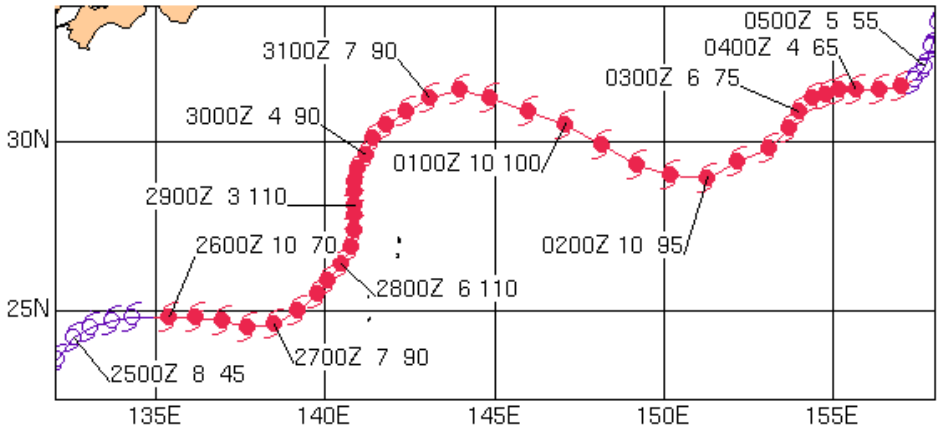


Figure 3-06-2. Visible satellite image of TY Rex at 312334Z August, 1998 undergoing reintensification to a 100 kt cyclone after weakening to 90 kt.


0800Z 7 50
0700Z 37 55
0900Z 35 50
0600Z 12 55
2500Z 8 45
2400Z 10 35
2300Z 10 30
2212Z N/A 20
50N
40N
30N
20N
130E
140E
150E
160E
170E
180
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX


0500Z 5 55
0400Z 4 65
3100Z 7 90
0300Z 6 75
3000Z 4 90
0100Z 10 100
2900Z 3 110
2600Z 10 70
0200Z 10 95
2800Z 6 110
2700Z 7 90
2500Z 8 45
30N
25N
135E
140E
145E
150E
155E

Tropical Depression 07W

Tropical Depression (TD) 07W developed east of Taiwan along the trailing edge of a stationary front. The first warning was issued on 020900Z September as a 30 kt system. Although convection did periodically increase, this Depression failed to intensify.

After forming just east of Taiwan, TD 07W tracked rapidly northeastward under the steering influence of the 700mb subtropical ridge to the south. The system began to accelerate and turned more east-northeastward as moderate vertical shear began to displace the cyclone's convection away from the low-level circulation center. TD 07W slowed on 040000Z September, and vertical wind shear increased, caused by the outflow of nearby Typhoon Rex (06W). TD 07W dissipated over water, with the final warning issued on 040900Z September.

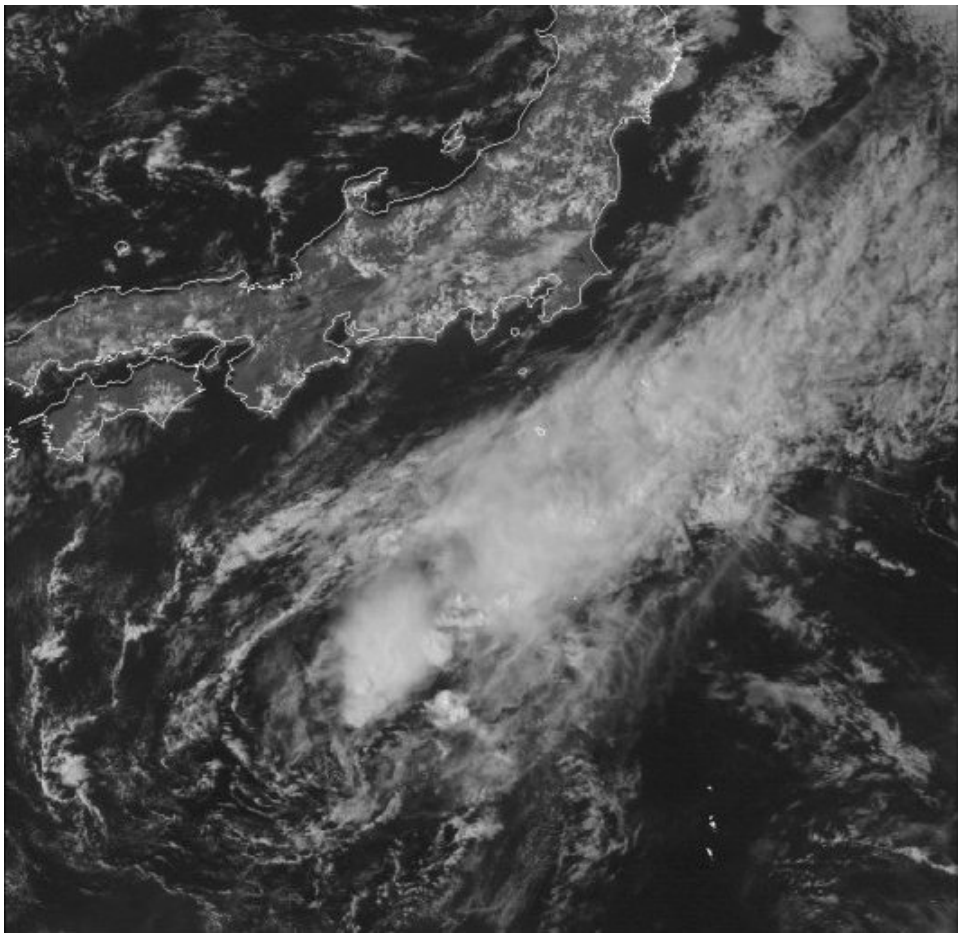
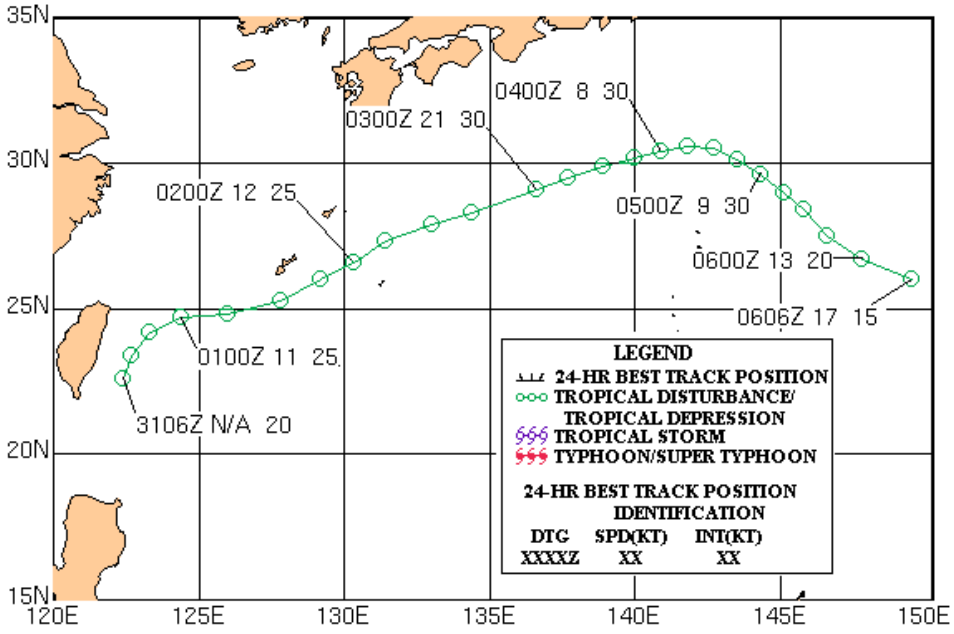


Figure 3-07-1. GMS-5 visible image of TD 07W at 030534Z September. Convection is being sheared to the northeast.


35N
30N
25N
20N
15N
120E
125E
130E
135E
140E
145E
150E
0400Z 8 30
0300Z 21 30
0200Z 12 25
0500Z 9 30
0600Z 13 20
0606Z 17 15
0100Z 11 25
3106Z N/A 20
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Typhoon Stella (08W)

Typhoon Stella (08W) began as a weak tropical disturbance just east of the northern Marianas Islands. The first warning was issued on 120900Z September as a tropical depression. The cyclone tracked northwestward for two days before reaching peak intensity and curving northeastward. This northeast turn took TY Stella along the eastern Honshu coast as it accelerated and became extratropical.

JTWC first mentioned this disturbance at 110600Z September on the Significant Tropical Weather Advisory. At 120000Z September, the disturbance was upgraded to a Tropical Cyclone Formation Alert. The first warning was issued at 120900Z September. TY Stella developed in the eastern portion of the monsoon trough, south of the subtropical ridge and tracked northwestward. TY Stella reached typhoon intensity as it moved into a weakness in the ridge and began transitioning into a poleward-oriented, steering pattern at 151200Z September. TY Stella tracked northeastward and continued to accelerate as it began to be influenced by the mid-latitude westerlies. TY Stella made landfall about 151800Z September near Numazu, Japan at minimum typhoon intensity. TY Stella became extratropical (XT) at 161200Z September. Once it became XT, it accelerated to 58 kt while maintaining an intensity of 60 kt. JTWC issued 18 warnings, with the final warning issued on 161500Z September.

CNN Tokyo (CNN, 17 Sep 1998) reported huge waves (23 feet), floods, heavy rains (14 inches in 24 hours), landslides, and four deaths.

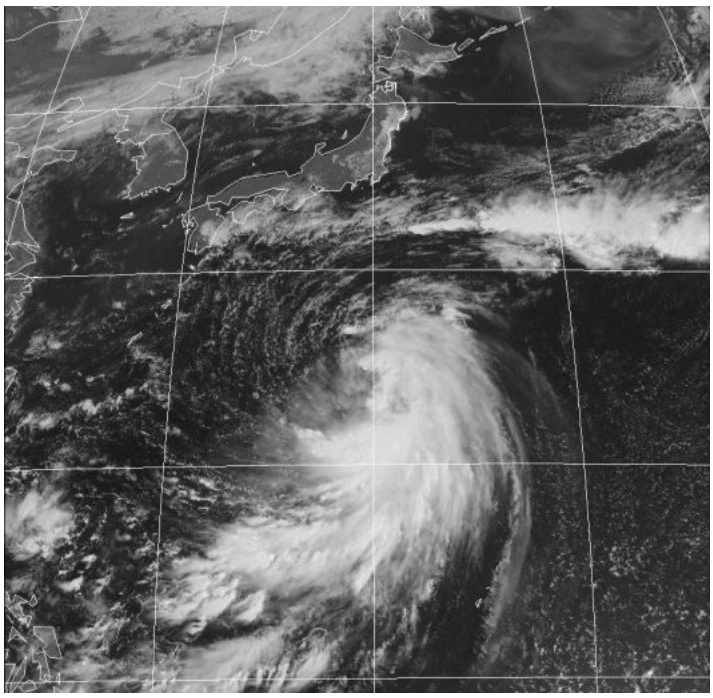
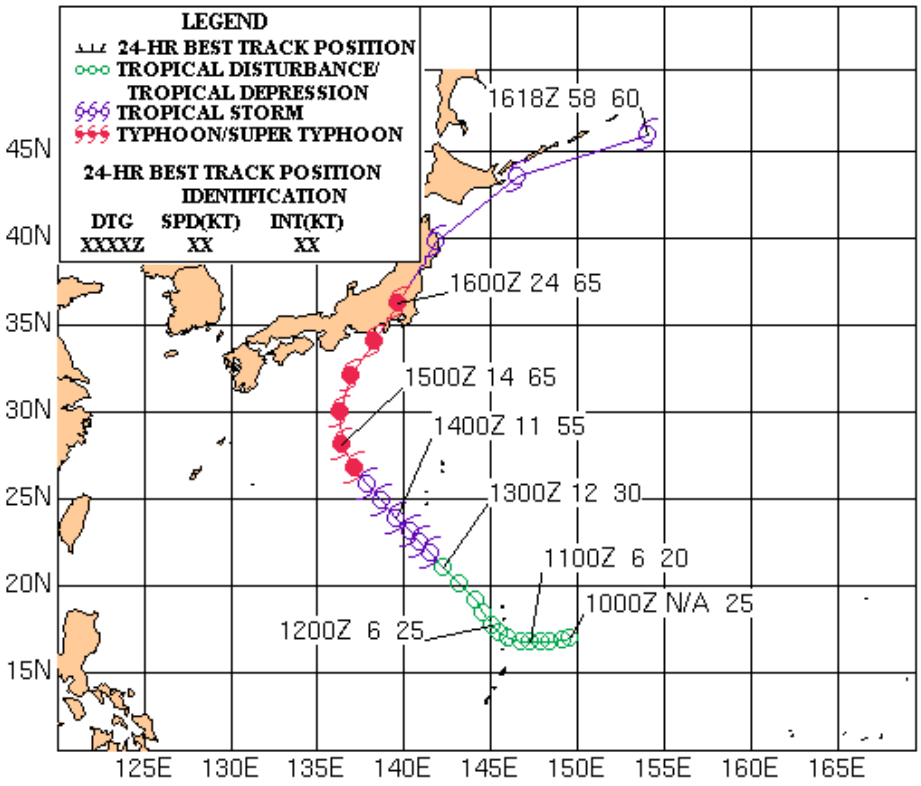


Figure 3-08-1. GMS-5 140034Z September visible image of Tropical Storm Stella (60 kt).


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
1618Z 58 60
1600Z 24 65
1500Z 14 65
1400Z 11 55
1300Z 12 30
1100Z 6 20
1000Z N/A 25
1200Z 6 25
45N
40N
35N
30N
25N
20N
15N
125E
130E
135E
140E
145E
150E
155E
160E
165E

Tropical Depression 09W

Tropical Depression (TD) 09W developed in the monsoon trough east of Hainan Island in the South China Sea on 13 September. TD 09W was a short-lived, minimum intensity tropical depression.

JTWC first mentioned this disturbance on 120600Z September on the Significant Tropical Weather Advisory (ABPW). JTWC issued the first warning on 130900Z September. TD 09W developed within the monsoon trough about 250nm east of Hainan Do, China. TD 09W, south of the subtropical ridge, tracked westward at 10-15 kt with the low-level steering flow. TD 09W reached a maximum intensity of 25 kt as it moved through the Hainan Strait Channel, into the Gulf of Tonkin. It made landfall and dissipated over Vietnam. JTWC issued three warnings. The final warning was issued at 132100Z September.

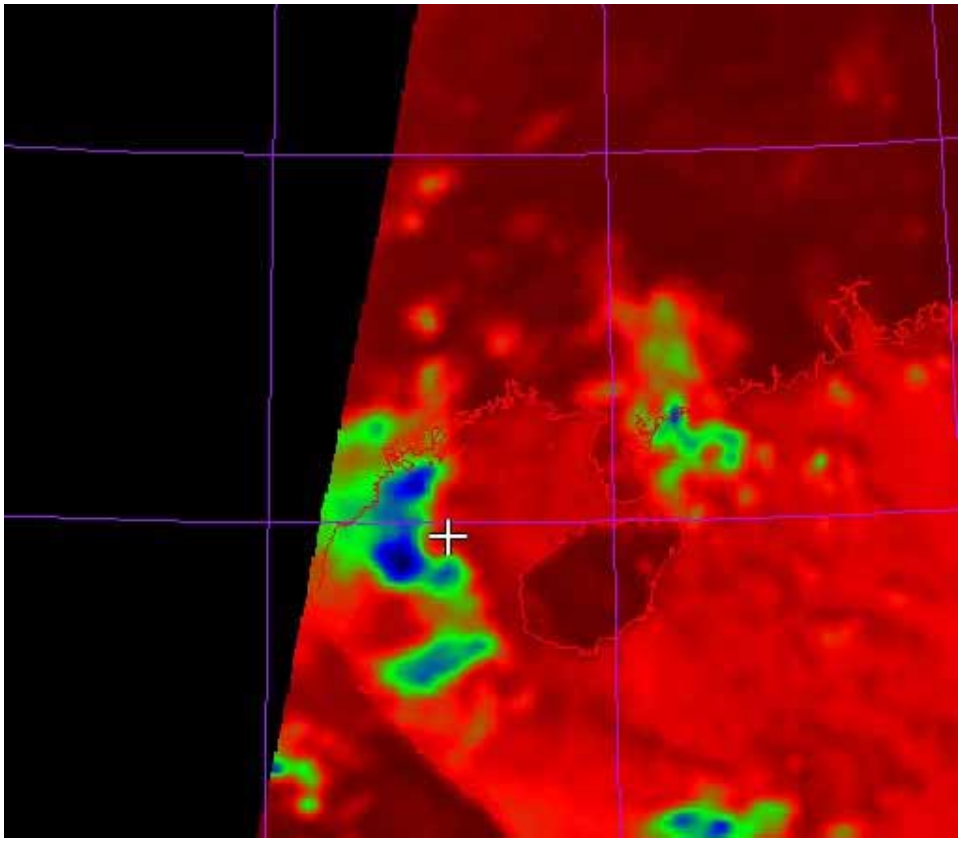
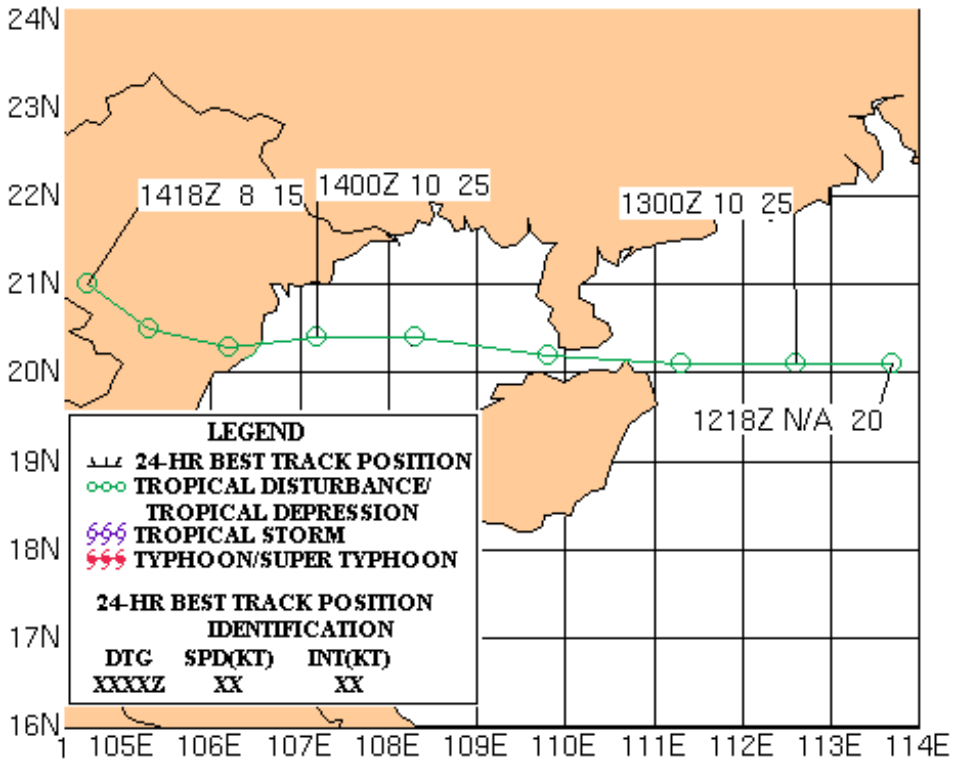


Figure 3-09-1. 132227Z September SSM/I pass. Convection is limited to west side of TD 09W. Low-level center is about 45 nm north of cursor location.


24N
23N
22N
21N
20N
19N
18N
17N
16N
1
105E
106E
107E
108E
109E
110E
111E
112E
113E
114E
1418Z 8 15
1400Z 10 25
1300Z 10 25
1218Z N/A 20
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Super Typhoon Todd (10W)

Super Typhoon (STY) Todd (10W) formed in the Philippine Sea within a reverse oriented monsoon trough. Initially detected in mid September, STY Todd (10W) developed rapidly while moving cyclonically in response to mid-tropospheric steering flow and the influence of a monsoon gyre located in the South China Sea. STY Todd (10W) attained a maximum intensity of 130 kt then dissipated in the East China Sea 6 days after initial formation.

JTWC issued a Tropical Cyclone Formation Alert at 150900Z September. The disturbance was embedded in a large area of deep convection, which masked its initial intensification. JTWC issued the first warning with a maximum intensity of 45 kt at 160300Z September. This initial warning forecast northeast movement and typhoon intensity at 48 hours. However, by 170600Z September, STY Todd had reached its peak intensity of 130 kt with an observed 12 nm diameter cloud-filled eye while moving northeastward at 11 kt.

Between 170000Z and 180000Z STY Todd began to change direction and accelerate in response to the steering flow of a developing anticyclone over Kyushu and a monsoon gyre in the South China Sea. As a result, STY Todd attained a maximum speed of movement of 30 kt between 171800Z and 180000Z September.

After 171200Z September, STY Todd experienced increased vertical wind shear, weakening and moving westward. When STY Todd made landfall on the east coast of China, 85 nm south of Shanghai, it had weakened to a 55 kt system and continued to weaken as it moved westward over land. After 200000Z September, however, the cyclone reversed course and the exposed low-level circulation turned eastward and tracked into the East China Sea. The remnants of STY Todd became quasi-stationary and dissipated. JTWC issued its final warning at 200300Z September.

Although Kyushu did not experience passage of the cyclone center, heavy rains from STY Todd caused seven fatalities from flooding and mudslides. No reports of fatalities or damage in China were available at the time of this report.

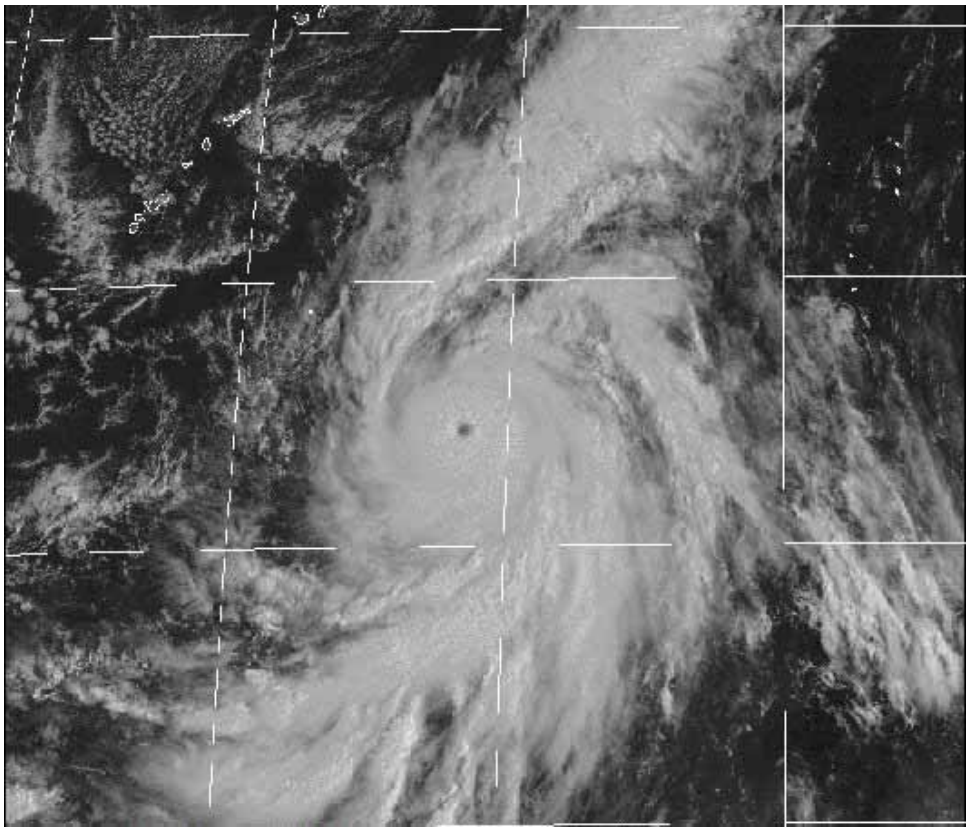


Figure 3-10-1. Visual Satellite image of Typhoon Todd at 2334Z on the 16th of September. At this point, TY Todd is a 120 kt system and will reach its maximum intensity of 130 kt within a few hours.

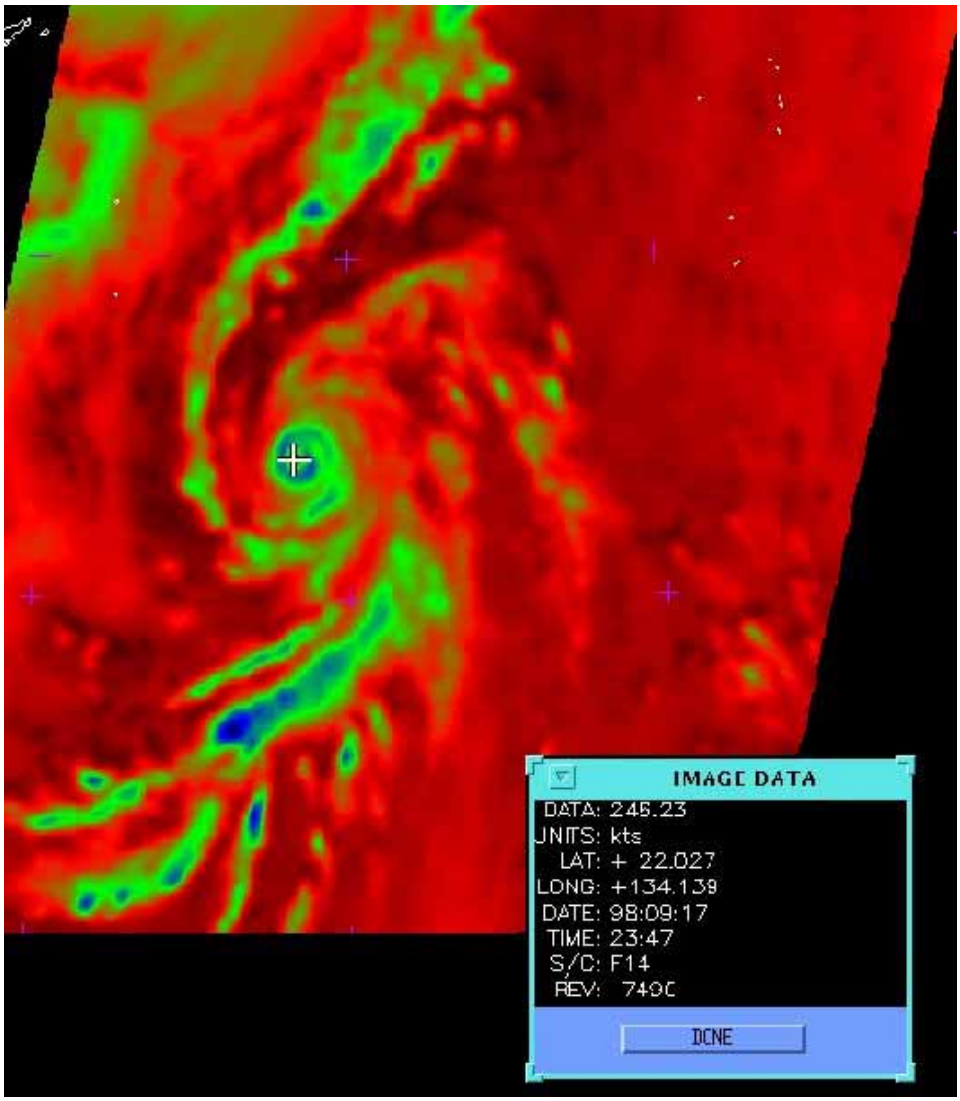


Figure 3-10-2. 172347Z September Special Sensor Microwave Image of STY Todd as an 80 kt system.

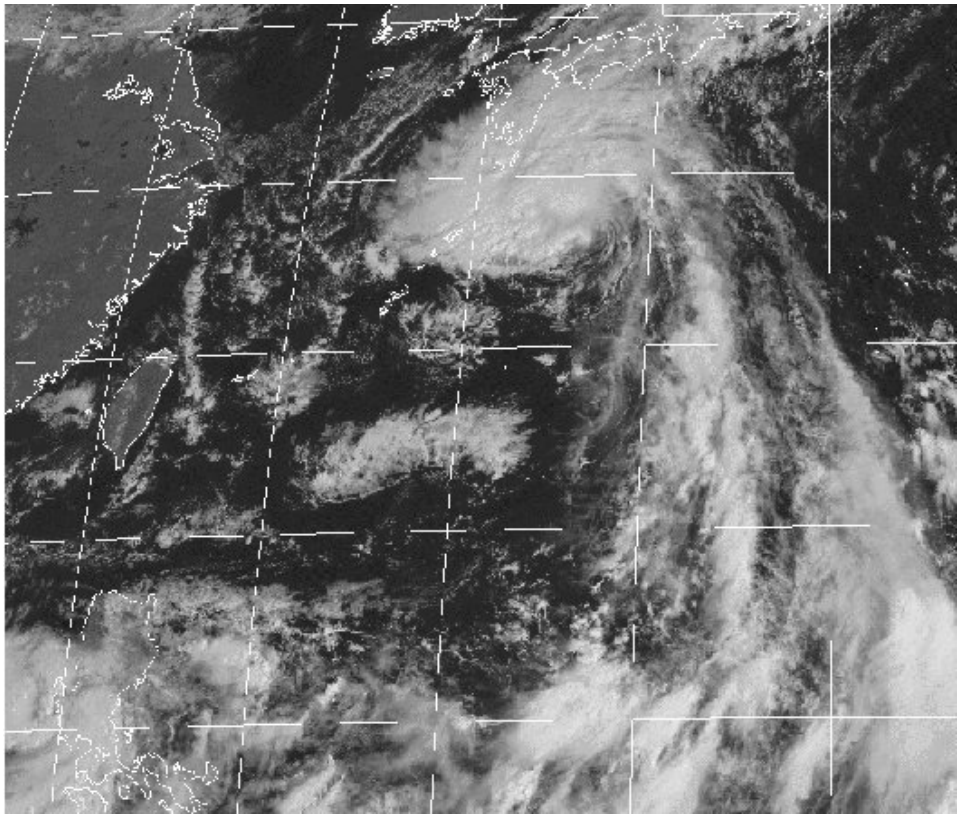
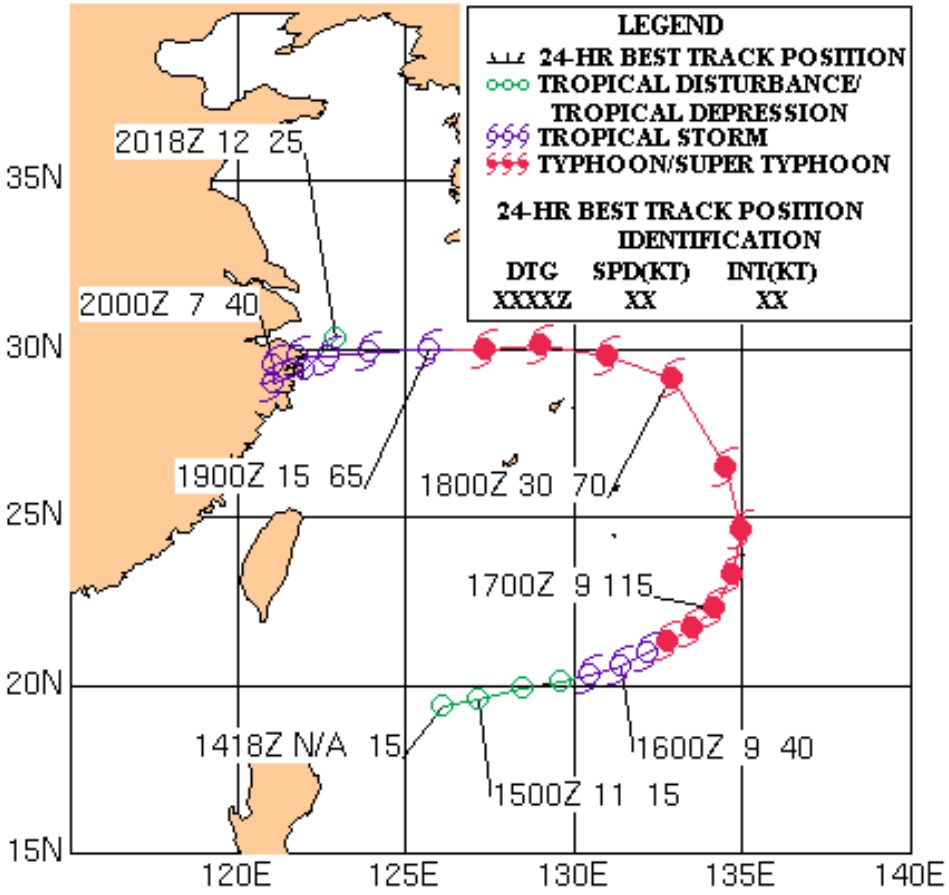


Figure 3-10-3. Visible imagery indicating STY Todd is experiencing vertical wind shear as shown by the partially exposed low level circulation. Application of the Dvorak Technique indicates STY Todd (10W) has a maximum intensity of 80 kt at this time.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
2018Z 12 25
2000Z 7 40
1900Z 15 65
1800Z 30 70
1700Z 9 115
1600Z 9 40
1500Z 11 15
1418Z N/A 15
35N
30N
25N
20N
15N
120E
125E
130E
135E
140E

Typhoon Vicki (11W)

TY Vicki (11W) developed in the South China Sea and moved eastward, reaching typhoon intensity before crossing Luzon. After passage into the Philippine Sea, the cyclone re-intensified and re-attained typhoon intensity east of Okinawa. TY Vicki continued its northeastward track over Shikoku and Honshu before becoming an extratropical cyclone.

JTWC issued a Tropical Cyclone Formation Alert at 160530Z September for an area of persistent convection with an associated low-level circulation center. The first warning was issued at 170300Z September as a 30 kt tropical depression.

TY Vicki (11W) began tracking slowly toward the east-southeast under the steering influence of the 700mb subtropical ridge to the south. The system intensified while approaching the west coast of Luzon. TY Vicki reached tropical storm strength by the 171200Z warning, and typhoon strength by the 180600Z warning. TY Vicki made its first landfall over western Luzon as an 85 kt typhoon and began tracking under the steering influence of the building mid-level subtropical ridge to the east. TY Vicki weakened to a 40 kt system due to interaction with land.

Once over open water, Typhoon Vicki began accelerating northeastward while slowly re-intensifying to typhoon strength by the 210000Z September warning. TY Vicki remained in a favorable environment while tracking at 16 to 27 kt toward Shikoku and Honshu in southwestern Japan. This strong steering flow was caused by the subtropical ridge to the east of the system and an approaching mid-latitude trough to the northwest. TY Vicki made its second landfall between 220000Z and 220600Z south of Osaka, Japan, as a 90 kt system. The system began weakening over land as it continued to accelerate within the strong westerly flow over central Japan. TY Vicki began to undergo extratropical transition as the mid-latitude interaction increased. The system became fully extratropical and the final warning was issued on 230300Z September.

CNN reported (19 September) that TY Vicki moved over Luzon killing 9 people and affected more than 300,000 people with severe flooding and a landslide that forced hundreds of people from their homes in several villages near Manila, Philippines. On 18 September, the ferry "Princess of the Orient" sank near the mouth of Manila Bay as it was heading for the city of Cebu. Dozens perished as the ferry sank with 430 people onboard. On 22 September, TY Vicki made a second landfall about 300 miles southwest of Tokyo, disrupting train and passenger service and canceling over 60 domestic flights in Japan.

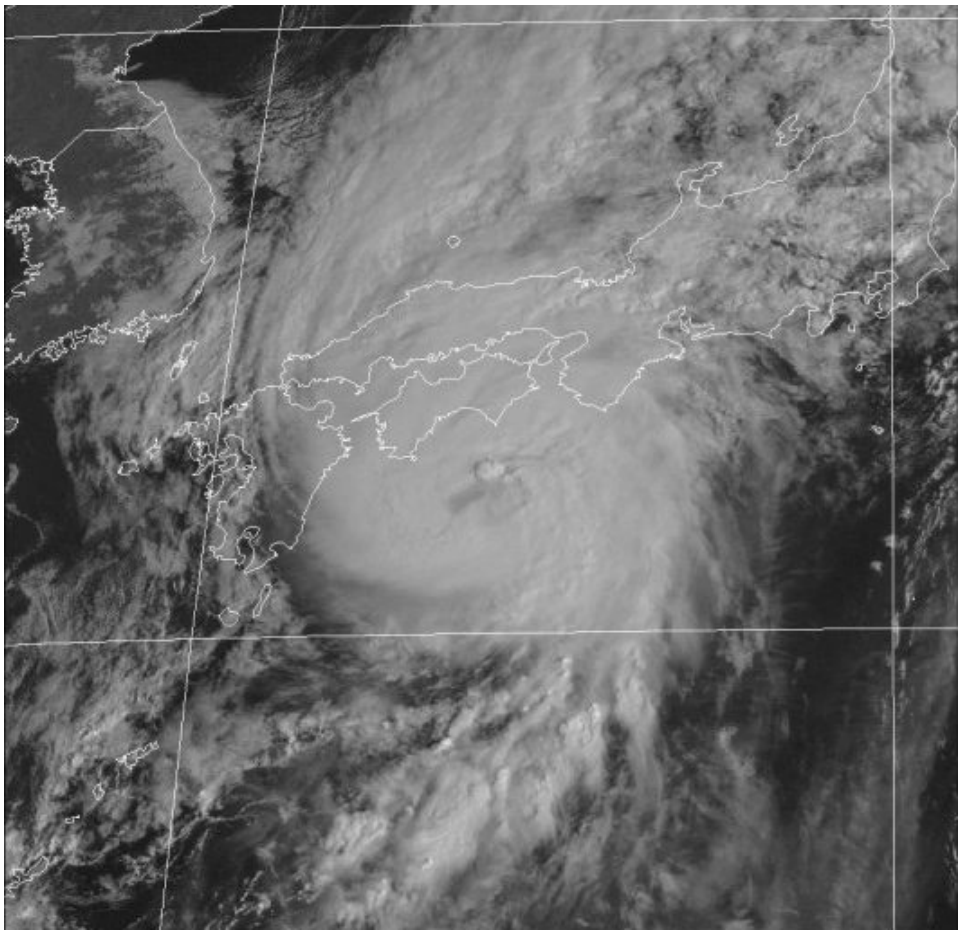
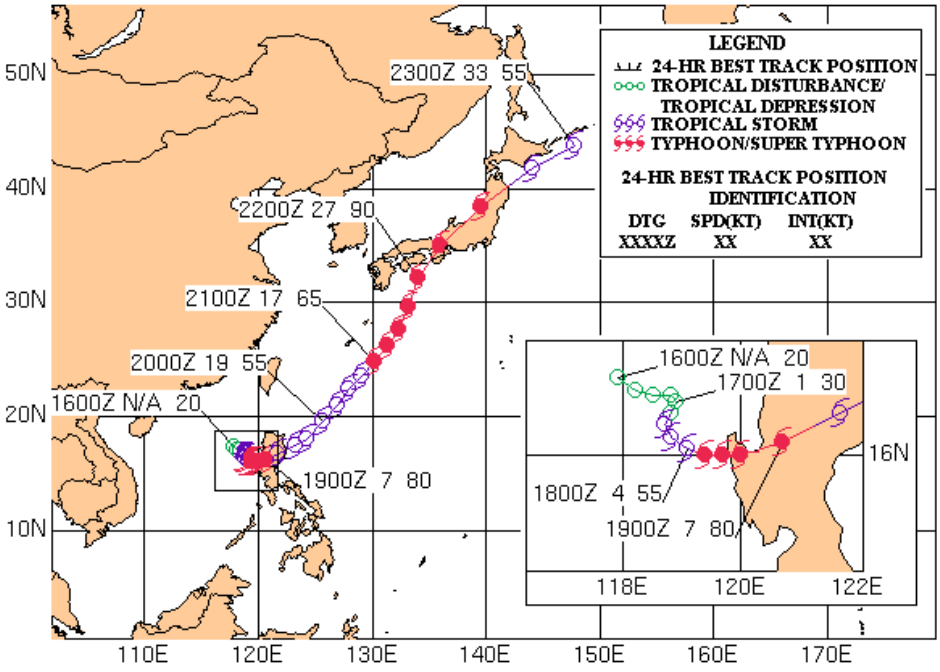


Figure 3-11-1. GMS-5 visible image of Typhoon Vicki (11W) at peak intensity (90 kt).


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
2300Z 33 55
2200Z 27 90
2100Z 17 65
2000Z 19 55
1600Z N/A 20
1900Z 7 80
1600Z N/A 20
1700Z 1 30
1800Z 4 55
1900Z 7 80
50N
40N
30N
20N
10N
110E
120E
130E
140E
150E
160E
170E
16N
118E
120E
122E

Tropical Depression 12W

Tropical Depression (TD) 12W formed in the South China Sea on 18 September, then moved northwest and made landfall in Vietnam 36 hours later. It remained a poorly organized system, reaching a maximum intensity of 30 kt while 30 nm off the Vietnamese coast.

JTWC first mentioned this monsoon trough disturbance located off the Vietnam coast in the 170600Z September Significant Tropical Weather Advisory. On 171100Z September, a Tropical Cyclone Formation Alert was issued on the suspect area, and the first JTWC warning was issued at 180900Z September. TD 12W remained south of the mid-tropospheric subtropical ridge throughout its existence and as a result, tracked persistently northwestward. TD 12W made landfall near Cua Ho, Vietnam around 191800Z September and rapidly dissipated over land. After seven warnings, the final warning was issued on 192100Z September.

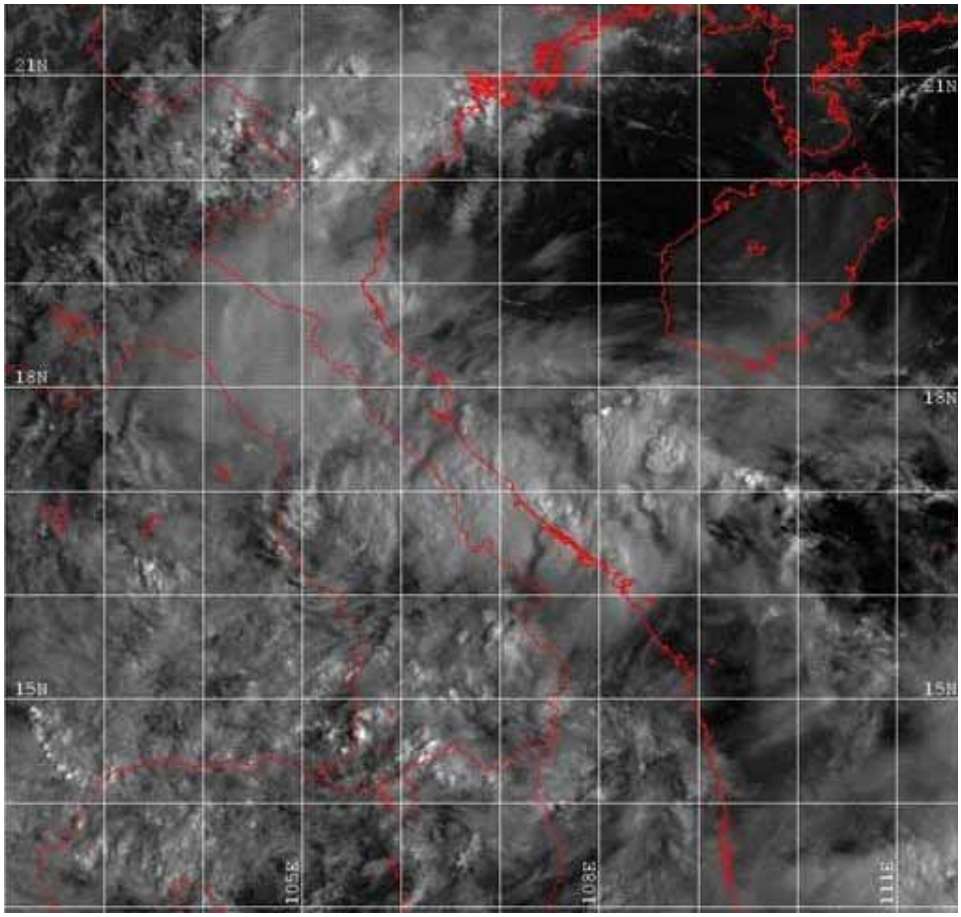
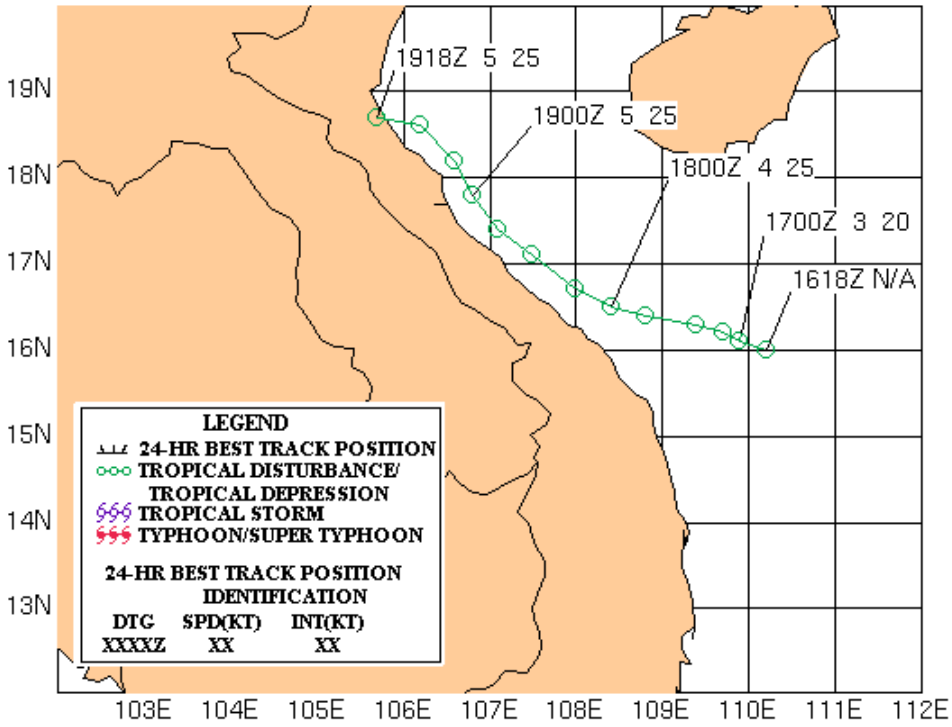


Figure 3-12-1. 190032Z GMS visible imagery indicating a poorly organized TD 12W moving toward the Vietnam coast.


1918Z 5 25
1900Z 5 25
1800Z 4 25
1700Z 3 20
1618Z N/A
19N
18N
17N
16N
15N
14N
13N
103E
104E
105E
106E
107E
108E
109E
110E
111E
112E
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Tropical Storm Waldo (13W)

Tropical Storm Waldo (13W), a small-sized tropical cyclone, developed in the Philippine Sea southwest of Iwo Jima around 20 September. It moved north and dissipated in the Sea of Japan on 21 September. The proximity of TY Vicki (11W), a larger cyclone, affected TS Waldo's movement and intensity.

JTWC issued a Tropical Cyclone Formation Alert at 190900Z September. The first warning was issued at 200300Z September. TS Waldo developed and moved faster than forecast, reaching tropical storm intensity at 200600Z September while moving north at 20 kt. The rapid acceleration northward was due to the proximity of TY Vicki (11W) to the southwest. JTWC forecasts called for TS Waldo to rotate cyclonically around TY Vicki and slowly intensify. Instead, TS Waldo moved northward and accelerated due to an increase in the synoptic scale southerly wind flow between TY Vicki and the mid-tropospheric subtropical ridge located to the northeast of TS Waldo. Additionally, the upper-level outflow from TY Vicki suppressed the outflow from TS Waldo, resulting in a 45 kt maximum intensity.

Landfall occurred near Owase, Japan on Honshu Island around 210800Z September. TS Waldo crossed Japan and dissipated over the Sea of Japan.

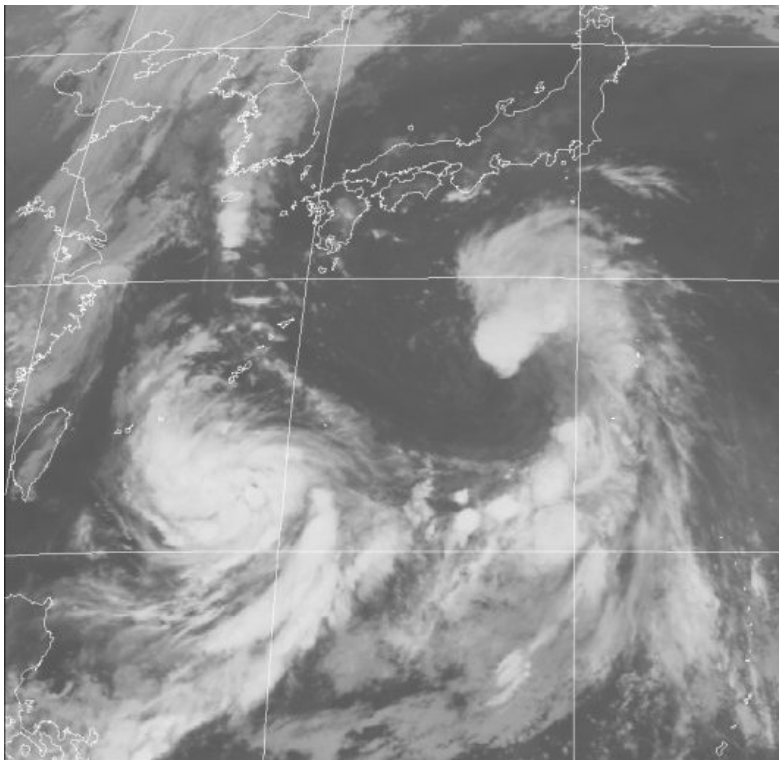
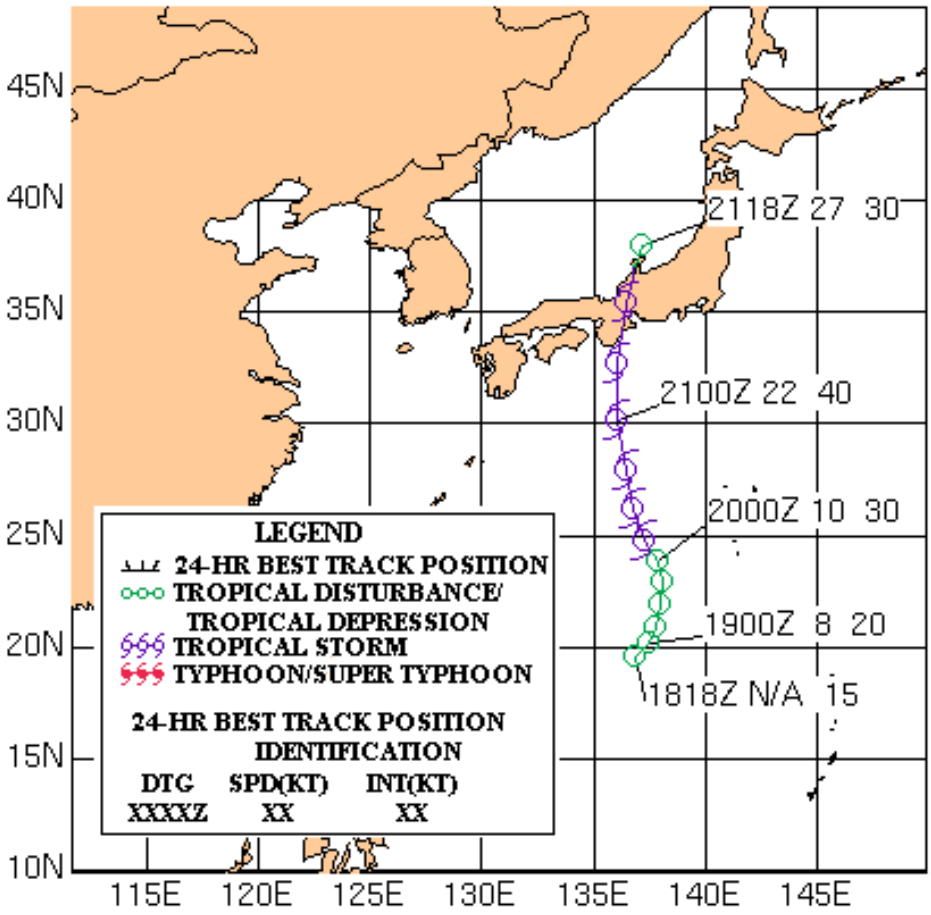


Figure 3-13-1. 201134Z September infrared satellite imagery when TS Waldo was a 35 kt system just south of Japan and TY Vicki (11W) was located southwest of TS Waldo and east of Taiwan.


45N
40N
35N
30N
25N
20N
15N
10N
115E
120E
125E
130E
135E
140E
145E
2118Z 27 30
2100Z 22 40
2000Z 10 30
1900Z 8 20
1818Z N/A 15
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Typhoon Yanni (14W)

Typhoon Yanni (14W) formed in the Philippine Sea and intensified slowly while moving northwestward. As TY Yanni approached Taiwan, this cyclone intensified to typhoon strength and moved northeastward toward Cheju Island, Republic of South Korea. TY Yanni weakened off the coast of Korea then turned south and dissipated near the Ryukyu Islands in the East China Sea.

A Tropical Cyclone Formation Alert was issued for TY Yanni on 242300Z September. JTWC issued the first warning at 250300Z September when TY Yanni was a 25 kt system moving northwestward. TY Yanni maintained a relatively steady track toward Taiwan and reached tropical storm intensity on 271200Z September. TY Yanni then slowed and began to move northward while continuing to intensify. The cyclone reached typhoon intensity on 280600Z while tracking north toward the Korean Peninsula at 8 kt. On 290000Z September, the cyclone accelerated and reached a maximum intensity of 80 kt.

TY Yanni began to weaken as it moved along the eastern periphery of the mid-tropospheric subtropical ridge and encountered more vertical wind shear. As TY Yanni passed over Cheju Island at 300000Z, it weakened to 55 kt. TS Yanni struck South Korea near Yeosu as a 50 kt system on 300700Z September.

After making landfall, Yanni became an exposed low level circulation. It tracked south-southeastward before dissipating near the Ryukyu Islands. The final warning was issued at 010900Z October.

According to a South Korean News Agency, TY Yanni killed 50 people and forced thousands to flee their homes.

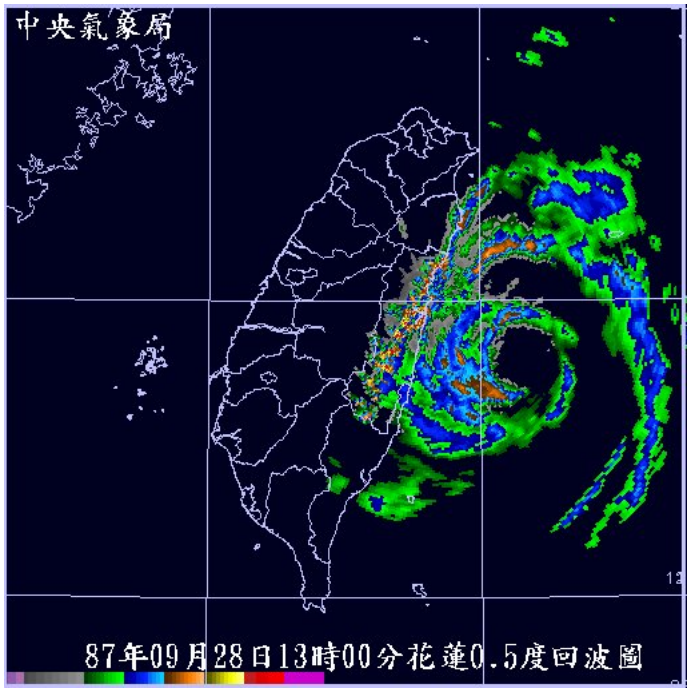


Figure 3-14-1. 2813001Z September Taiwan Doppler Radar depiction of Typhoon Yanni just after reaching typhoon intensity.

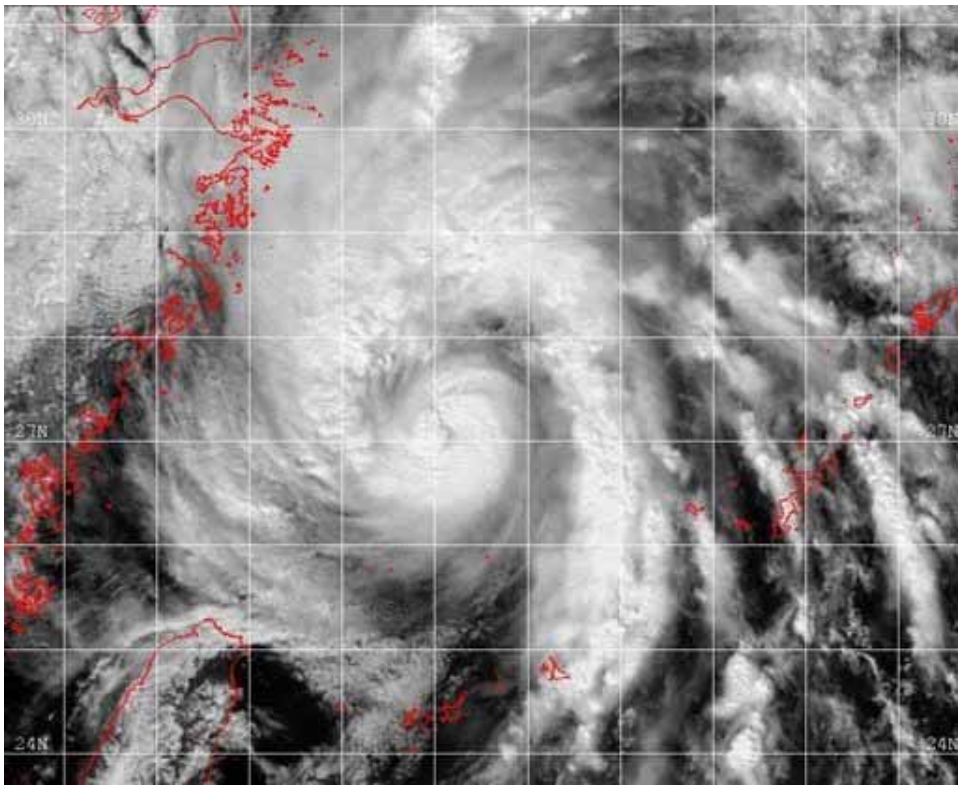
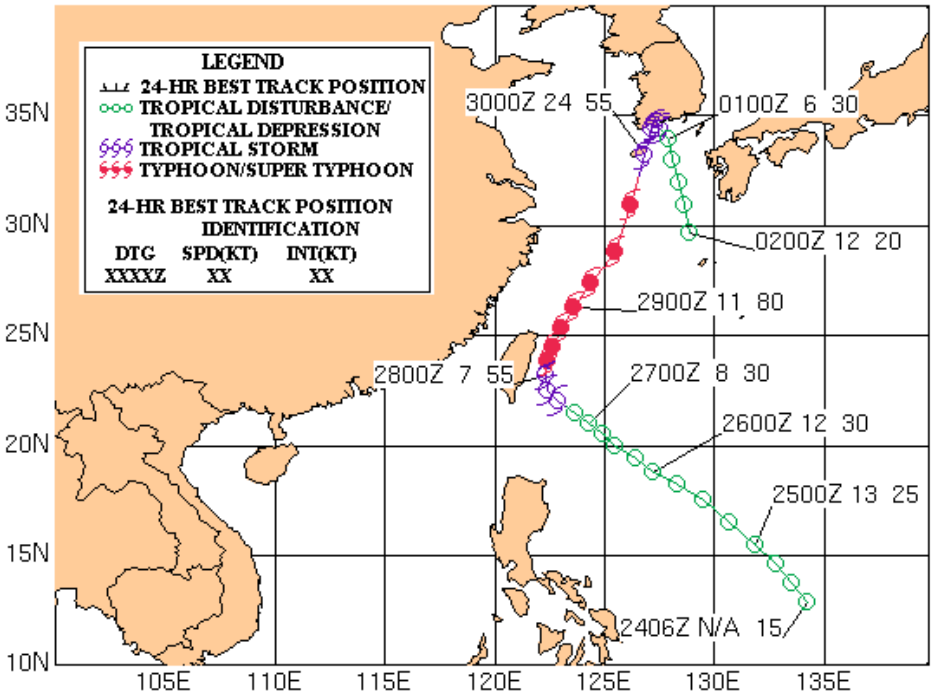


Figure 3-14-2. 280425Z visible satellite image of Typhoon Yanni northeast of Taiwan at it's maximum intensity of 80 kt, courtesy of the Taiwan Weather Agency.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
3000Z 24 55
0100Z 6 30
0200Z 12 20
2900Z 11 80
2800Z 7 55
2700Z 8 30
2600Z 12 30
2500Z 13 25
2406Z N/A 15
35N
30N
25N
20N
15N
10N
105E
110E
115E
120E
125E
130E
135E

Tropical Depression (15W)

Tropical Depression 15W, developed in a broad area of surface troughing in the South China Sea, and meandered northwest before dissipating over northern Vietnam less than 72 hours later.

JTWC issued a Tropical Cyclone Formation Alert at 020700Z October. The first warning was issued 030900Z October as a 30 kt tropical depression. Although initially forecast to reach tropical storm intensity, TD 15W, failed to develop due to vertical windshear. Southeasterly low level synoptic flow steered TD 15W steadily northwestward at 7 to 10 kt toward Vietnam. The cyclone made landfall near Vinh, Vietnam at 051200Z October with a maximum intensity of 30 kt.

Tropical Depression 15W dissipated quickly after moving over land and JTWC issued the final warning at 052100Z October.

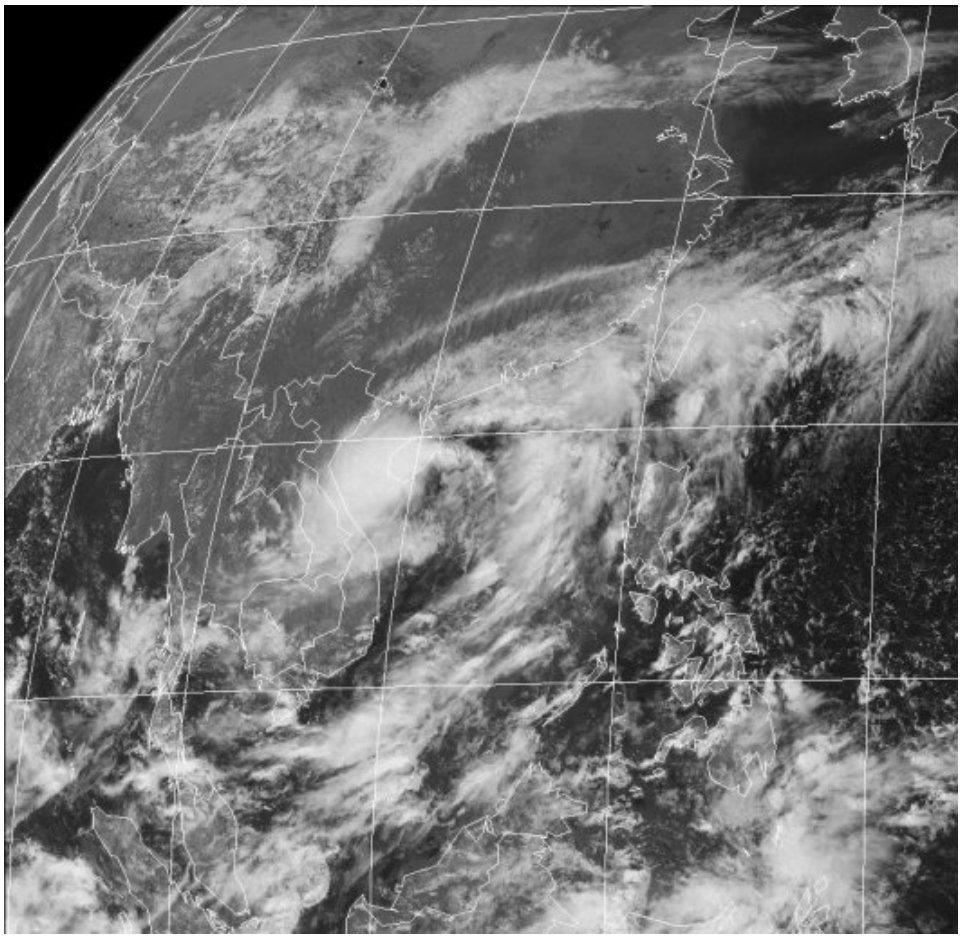
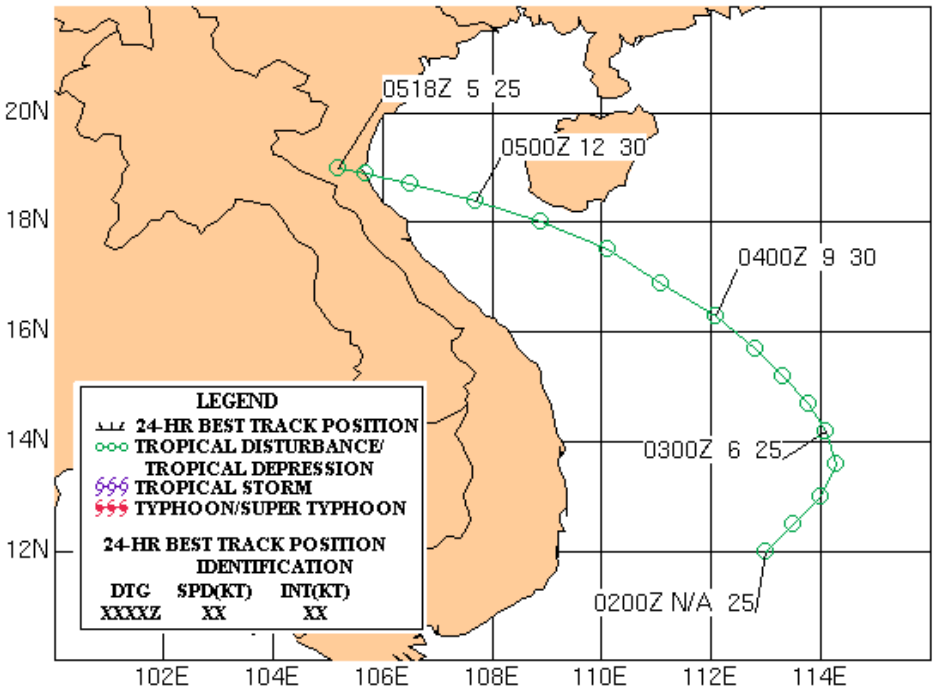


Figure 3-15-1. 040534Z October visible image of TD 15W when the cyclone was located just south of Hainan Island.


0518Z 5 25
0500Z 12 30
0400Z 9 30
0300Z 6 25
0200Z N/A 25
20N
18N
16N
14N
12N
102E
104E
106E
108E
110E
112E
114E
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Tropical Depression 16W

Tropical Depression 16W developed east of Taiwan, moved northeastward and then dissipated south of Okinawa in October.

This cyclone, which developed in a surface trough located over Taiwan and the Ryukyu Islands, was first mentioned in the Significant Tropical Weather Advisory on October 3rd as an area of persistent convection. JTWC issued a Tropical Cyclone Formation Alert at 041630Z October. The initial warning was issued at 050900Z as a 25 kt system located east of Taiwan.

TD 16W remained quasi-stationary in an area of weak steering flow for 36 hours and reached a peak intensity of 30 kt at 061200Z. A passing frontal boundary then moved the system east-northeastward. Vertical shear increased and by 070900Z, TD 16W was an exposed low-level circulation. JTWC issued the final warning at 072100Z October.

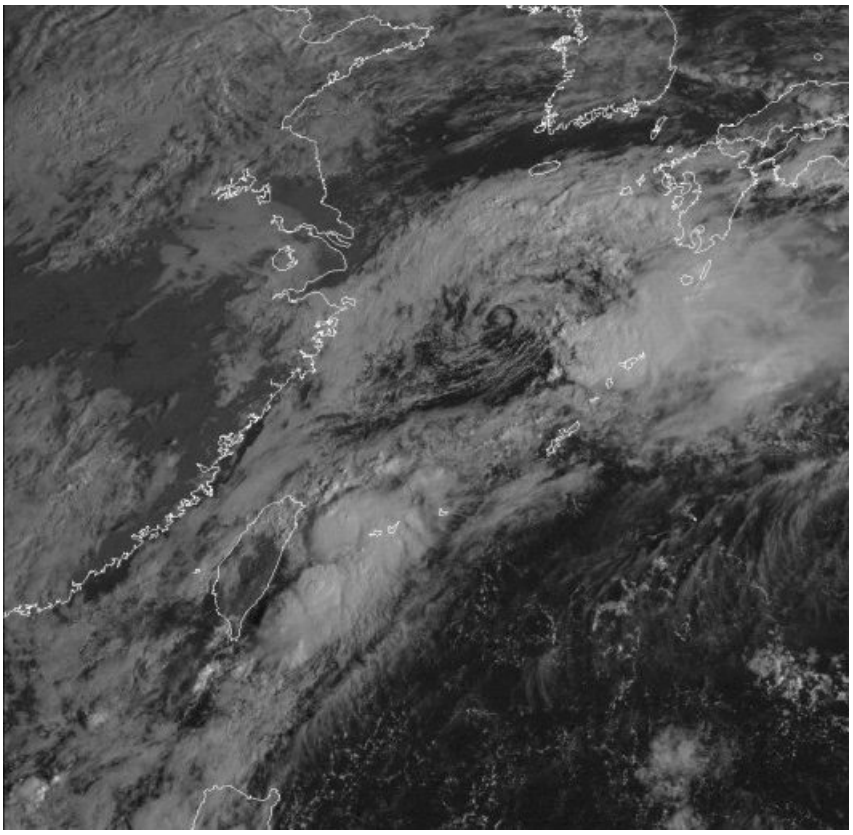
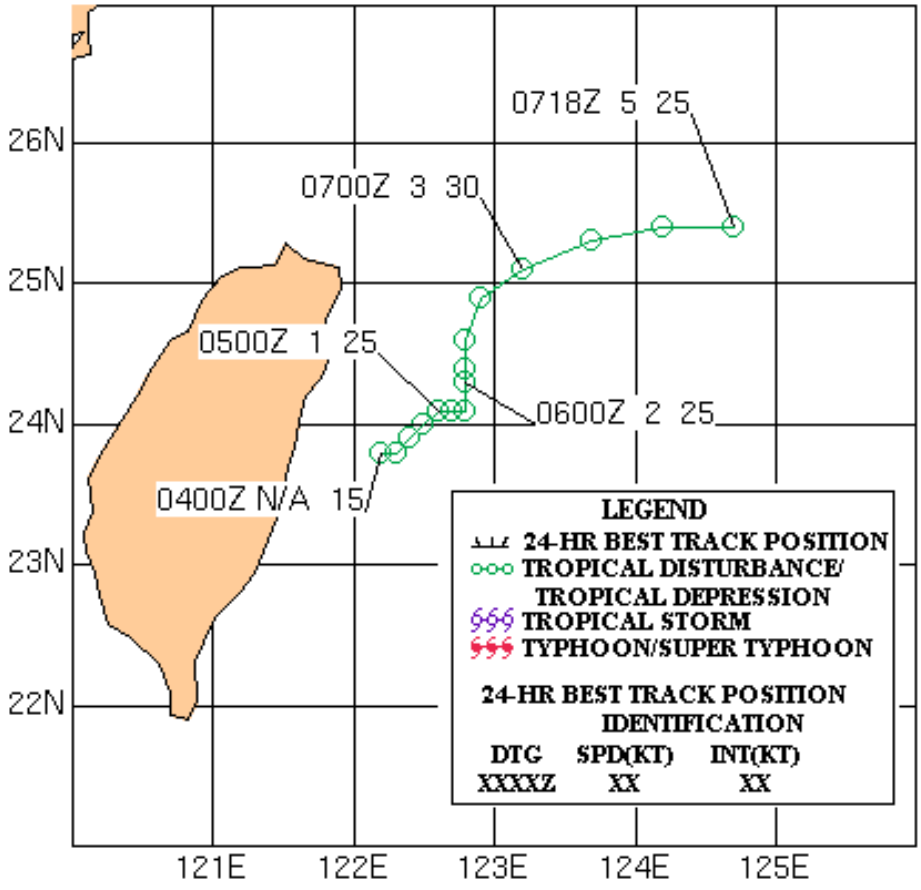


Figure 3-16-1. 052334Z October visual satellite image of TD 16W located east of Taiwan with maximum intensity of 25 kt. Also evident in this data is TD 17W as a completely exposed low level circulation in the East China Sea.


0718Z 5 25
0700Z 3 30
0500Z 1 25
0600Z 2 25
0400Z N/A 15
26N
25N
24N
23N
22N
121E
122E
123E
124E
125E
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Tropical Depression 17W

Tropical Depression 17W was a short-lived cyclone that developed and dissipated as an exposed low level circulation in the East China Sea during early October. Five warnings were issued by JTWC.

TD 17W formed in the reverse orientated monsoon trough and was initially detected by visual satellite data as an exposed low level circulation. The first warning was issued at 060300Z October.

TD 17W was forecast to remain weak as synoptic and satellite data indicated a high vertical wind shear environment. Within 12 hours, TD 17W weakened to a 20 kt system. JTWC issued the final warning at 070300Z October.

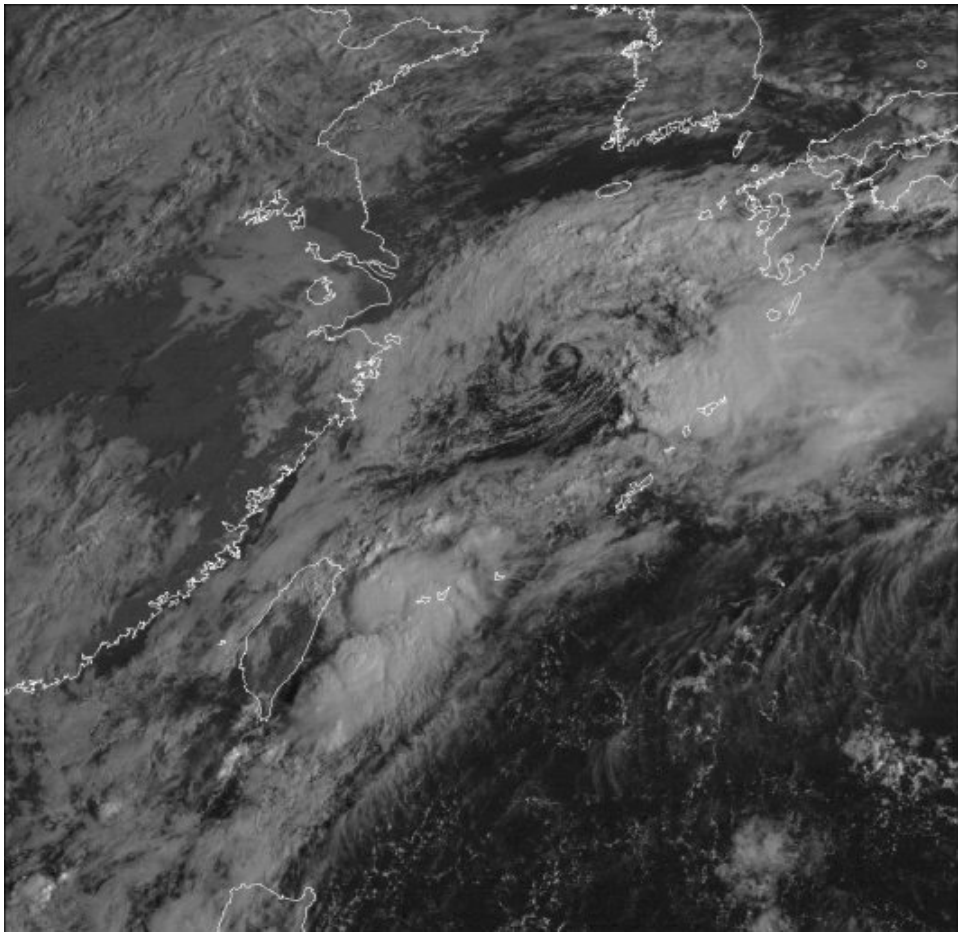
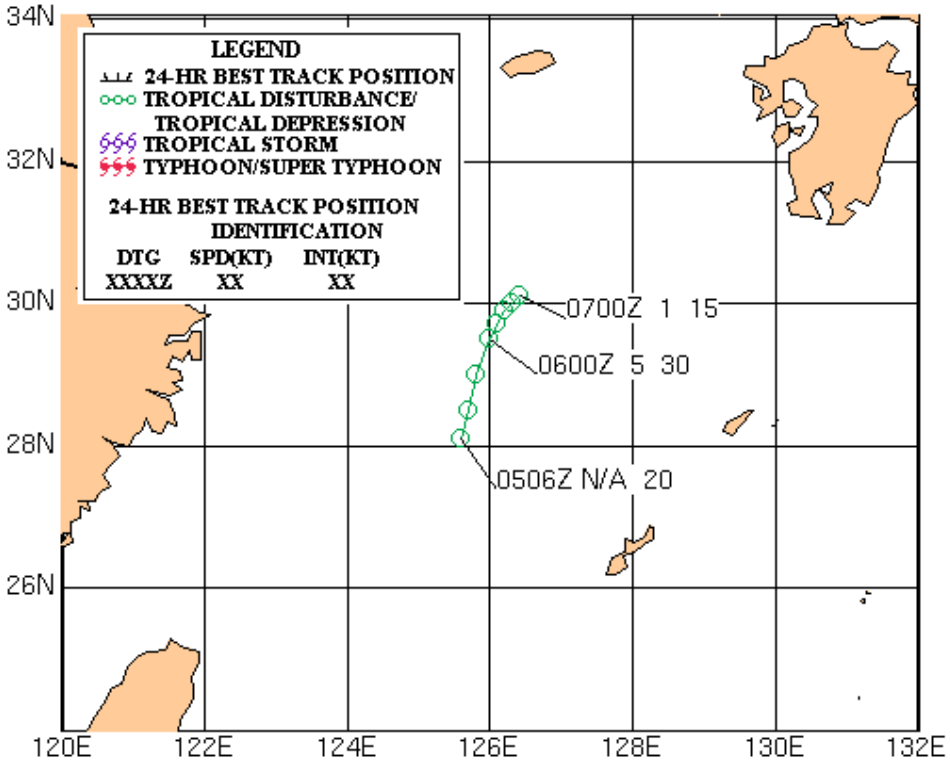


Figure 3-17-1. 052334Z October visible satellite data of TD 17W at maximum intensity of 30 kt with a totally exposed low level circulation.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
0700Z 1 15
0600Z 5 30
0506Z N/A 20
34N
32N
30N
28N
26N
120E
122E
124E
126E
128E
130E
132E

Super Typhoon Zeb (18W)

Super Typhoon (STY) Zeb (18W) formed in early October in the monsoon trough southeast of Guam and moved northwest passing over northern Luzon, then north and northeast passing east of Taiwan and over all four of the main Japanese islands. During its transit through the Philippine Sea, this cyclone attained super typhoon intensity of 155 kt just prior to a northern Luzon landfall.

A TCFA was issued on 090630Z October for a tropical disturbance located southeast of Guam. The first warning was issued at 092100Z October when the cyclone was southwest of Guam.

The cyclone intensified to tropical storm strength as it moved north of Yap Island. During intensification, the WSR-88D radar on Guam detected another cyclone embedded in the inflow. This new cyclone was warned on as TS Alex (19W).

TS Zeb (18W) was upgraded to a typhoon at 111800Z October. Zeb attained super typhoon intensity on 130000Z October and reached a peak intensity of 155 kt prior to landfall in the Philippines just south of Palanan Bay, Luzon Island. During passage over northern Luzon, STY Zeb (18W) began to weaken and moved north toward Taiwan. After passing just 10 nm east of Taiwan, the cyclone moved northeast and accelerated. The forward motion of the cyclone reached 48 kt as STY Zeb (18W) underwent extratropical transition over southern Japan and the Sea of Japan. The final warning was issued at 180300Z October.

STY Zeb (18W) was the first of two super typhoons to strike Luzon within 7 days STY Babs (20W) was the second). STY Zeb caused 74 deaths in Luzon and 25 fatalities in Taiwan.

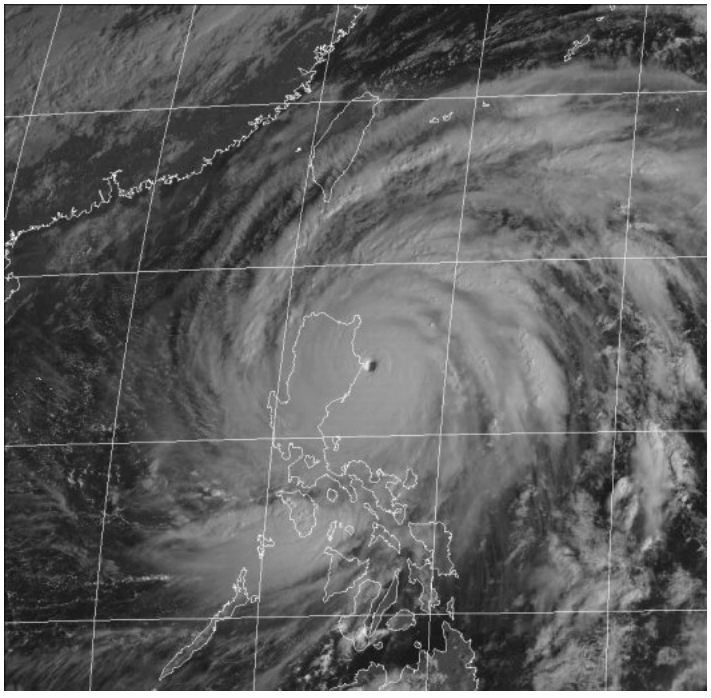
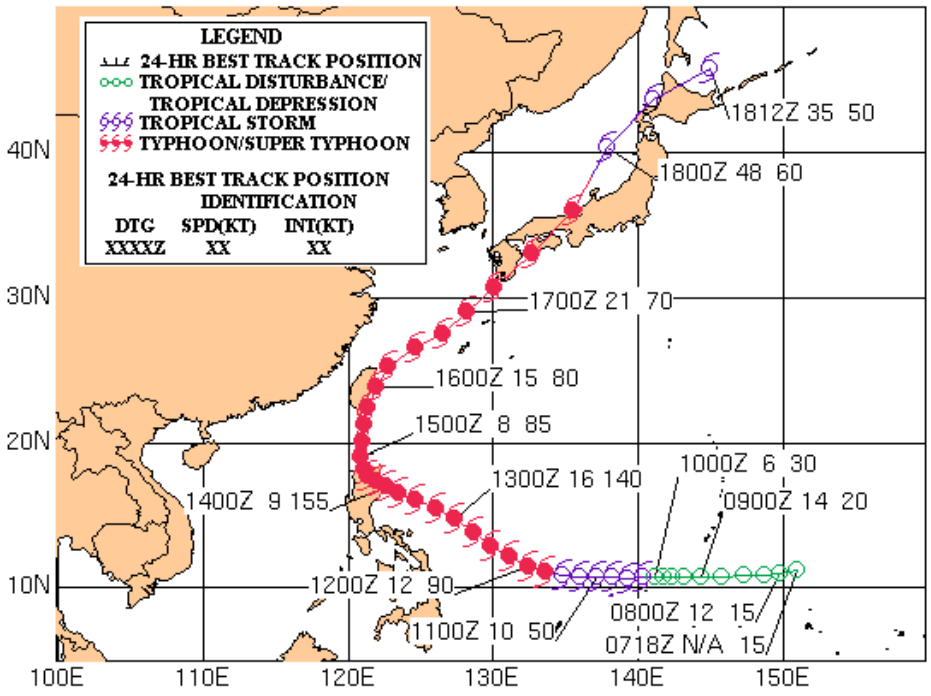


Figure 3-18-1. Super Typhoon Zeb (18W) at 155 kt intensity just before landfall over northern Luzon.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
40N
30N
20N
10N
100E
110E
120E
130E
140E
150E
1812Z 35 50
1800Z 48 60
1700Z 21 70
1600Z 15 80
1500Z 8 85
1400Z 9 155
1300Z 16 140
1200Z 12 90
1100Z 10 50
1000Z 6 30
0900Z 14 20
0800Z 12 15/
0718Z N/A 15/

Tropical Storm Alex (19W)

TS Alex (19W) was a very small tropical cyclone that formed in the northern inflow of STY Zeb (18W) when STY Zeb was an intensifying tropical storm. TS Alex (19W) existed for only 60 hrs and attained a maximum intensity of 45 kt before the cyclone became sheared in the vertical and the low level circulation was absorbed by STY Zeb (18W).

This cyclone was first detected on the Guam WSR-88D radar imagery while STY Zeb (18W) was passing north of Ulithi Island. The radar data as well as a 40 kt wind report from Rota Island resulted in the first warning, issued at 110300Z October.

TS Alex (19W) maintained westward movement north of Zeb until 120600Z October. TS Alex then turned southwestward and underwent vertical shearing. The remaining low level circulation center was absorbed by STY Zeb (18W). The final warning was issued at 122100Z October.

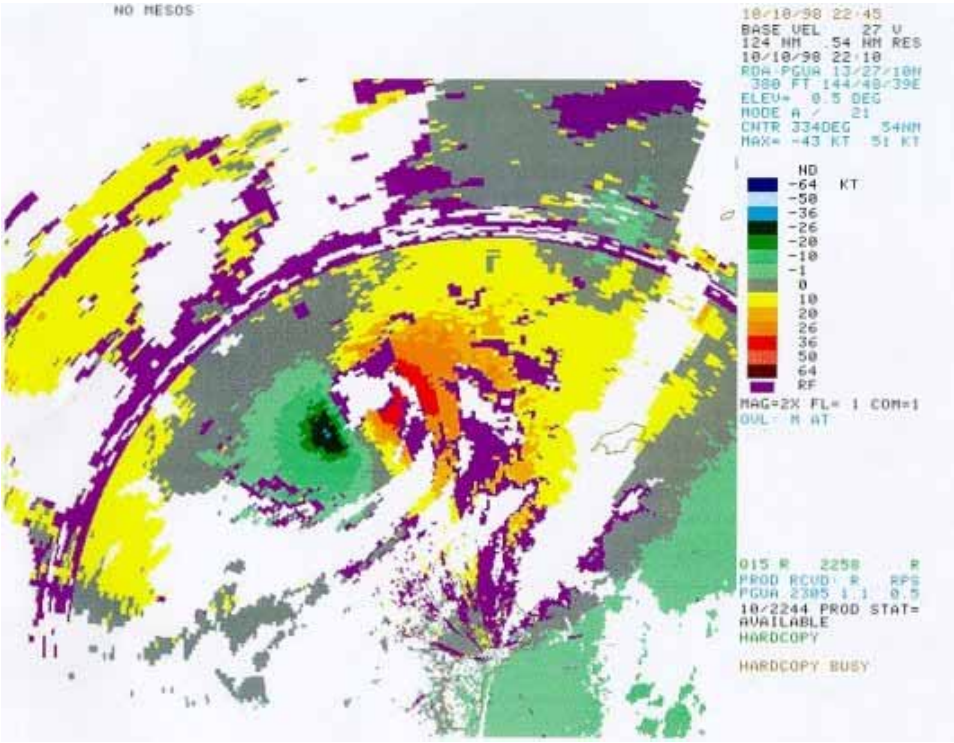
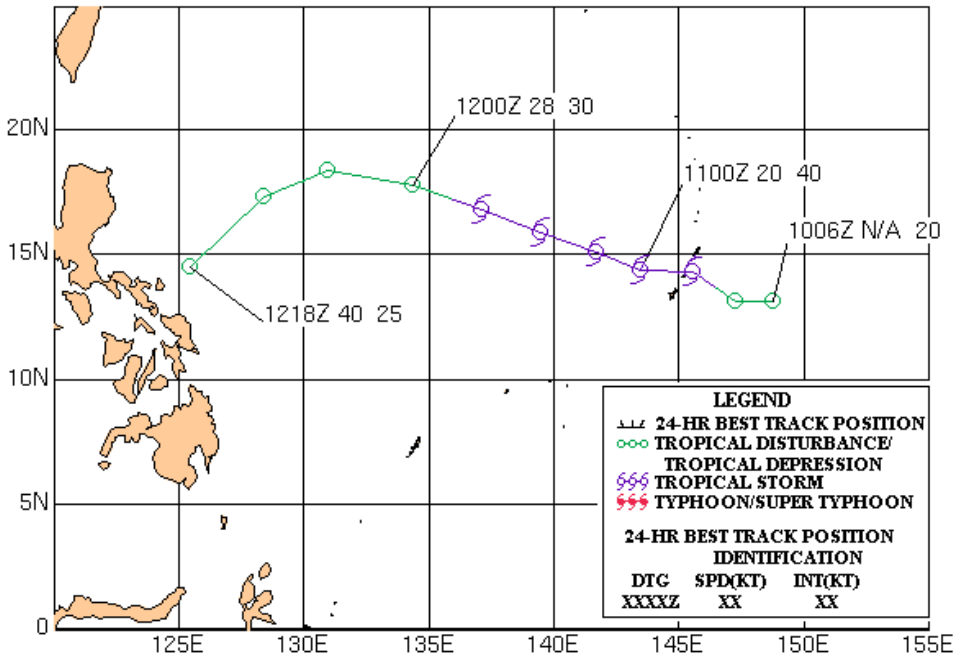


Figure 3-19-1. WSR-88D velocity profile data depicting TS Alex (19W) in a feeder band of STY Zeb (18W).


1200Z 28 30
1100Z 20 40
1006Z N/A 20
1218Z 40 25
20N
15N
10N
5N
0
125E
130E
135E
140E
145E
150E
155E
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Super Typhoon Babs (20W)

Super Typhoon Babs (20W), the second super typhoon within a 7-day period to strike the Philippines, was initially detected as a tropical disturbance southeast of Guam. While moving west and intensifying, interaction with a Tropical Upper Tropospheric Trough (TUTT) caused the cyclone to slow and move southward for a 36-hour period in the Philippine Sea. As the TUTT filled, TY Babs reached super typhoon intensity (maximum intensity of 135 kt) while moving northwestward off the coast of Mindanao. Passage over central Luzon caused Super Typhoon (STY) Babs to weaken, while steering currents caused a track change northward. A subsequent increase in vertical shear and proximity to land led to rapid weakening and dissipation in the Taiwan Strait.

The initial TCFA was issued at 120900Z October. The first warning was issued at 140900Z October. The system was upgraded to a tropical storm at 150600Z October as it moved westward toward the Philippines at 10 kt.

At approximately 171200Z, TY Babs began to weaken and move south in response to the influence of the TUTT located to the northeast. The TUTT weakened the sub-tropical ridge (thus the slowing and move south) and restricted the cyclone's upper level outflow (the short period of weakening). After the TUTT filled, TY Babs began to re-intensify and moved toward the Philippines, reaching super typhoon intensity on 201200Z October.

STY Babs continued to move northwestward across Cantanduanes and Polillo Islands before making landfall over central Luzon. During passage over Luzon, the cyclone weakened to 85 kt and tracked across the South China Sea where a mid-latitude trough further weakened it and steered it northward.

Super Typhoon Babs (20W) dissipated in the Taiwan Strait due to strong vertical wind shear and the frictional effects of land. The final warning was issued at 272100Z October.

News agencies reported Super Typhoon Babs had a significant impact throughout the Far East. In the Philippines, disastrous mudslides killed 156 people and displaced nearly 400,000 from their homes. In Taiwan, over 20 inches of rain fell in 24 hours, inundating many eastern towns and villages with waist-high flooding. Landslides also wreaked havoc in Taiwan, trapping hundreds in the mountainous interior. In Hong Kong, 64 mph winds closed beaches and kept the local fishing fleet in port.

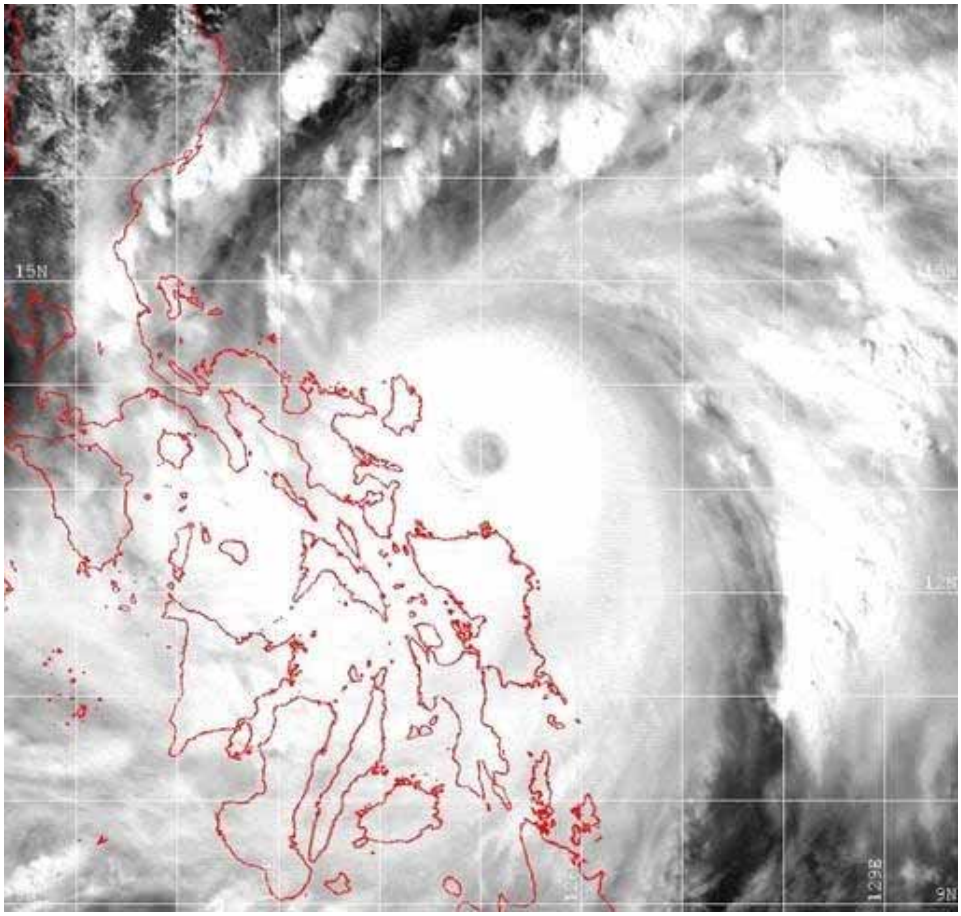
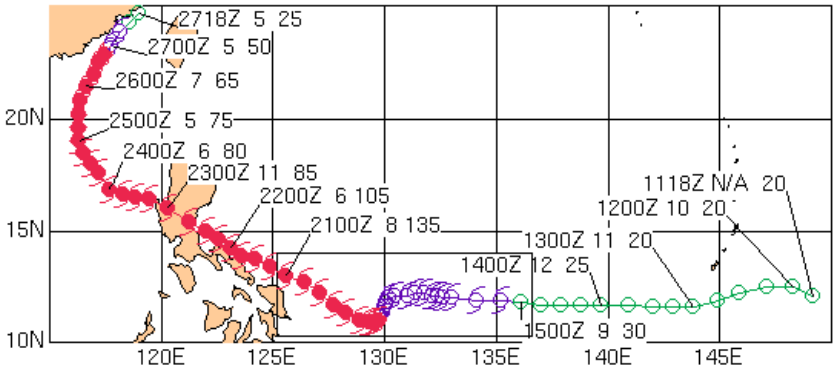
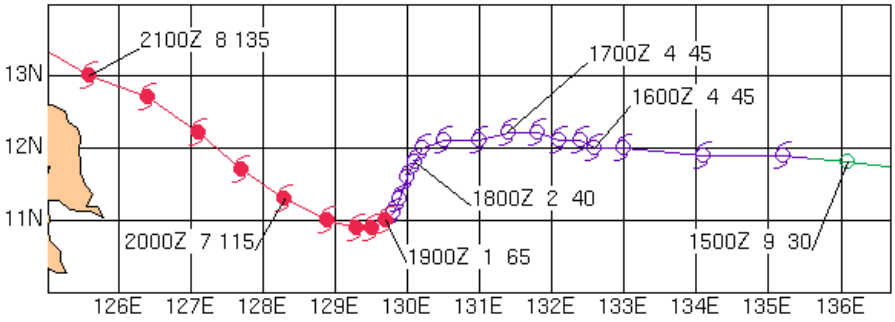


Figure 3-20-1. Visual imagery of Super Typhoon Babs (20W) as it passed over Cantanduanes Island, Philippines.





LEGEND

24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/ TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON

24-HR BEST TRACK POSITION IDENTIFICATION

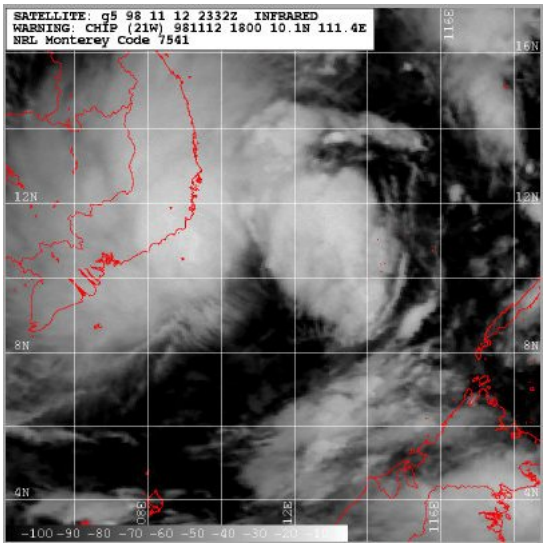
DTG	SPD(KT)	INT(KT)
XXXXZ	XX	XX

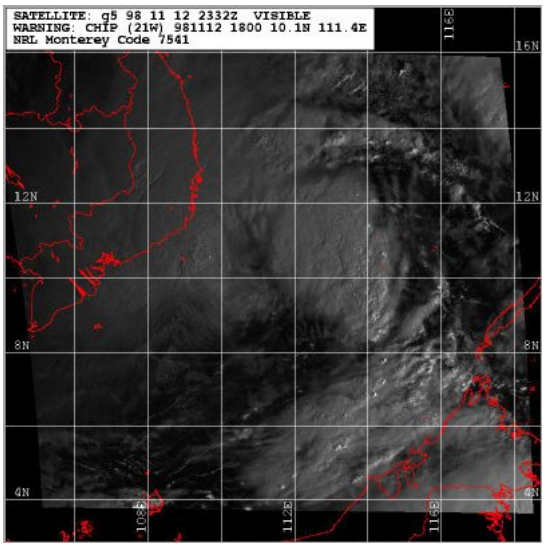
Tropical Storm Chip (21W)

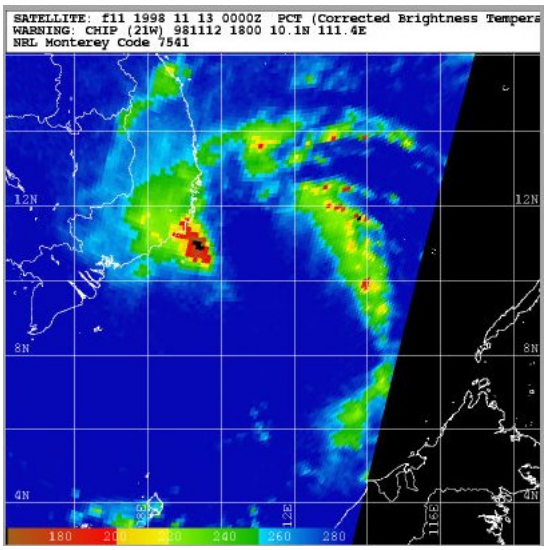
Tropical Storm Chip (21W) developed in mid-November as a shearline-enhanced circulation in the South China Sea, and existed for just over 72 hours before dissipating south of Vietnam.

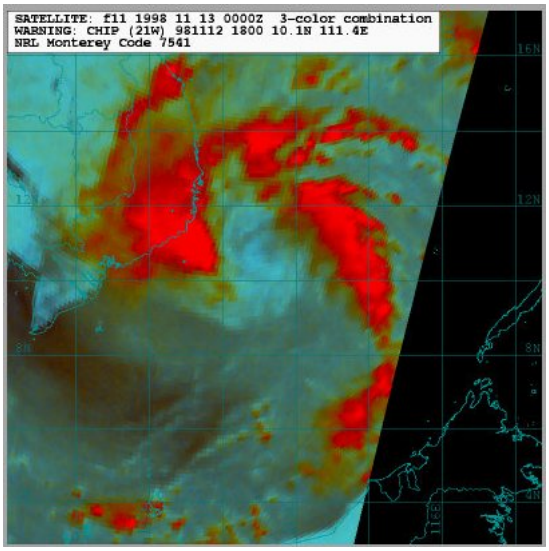
A TCFA was issued at 111230Z November when a broad cyclonic circulation became more organized as a shearline moved into the northern South China Sea. At 120300Z November, the first warning was issued when satellite and synoptic data indicated continued organization.

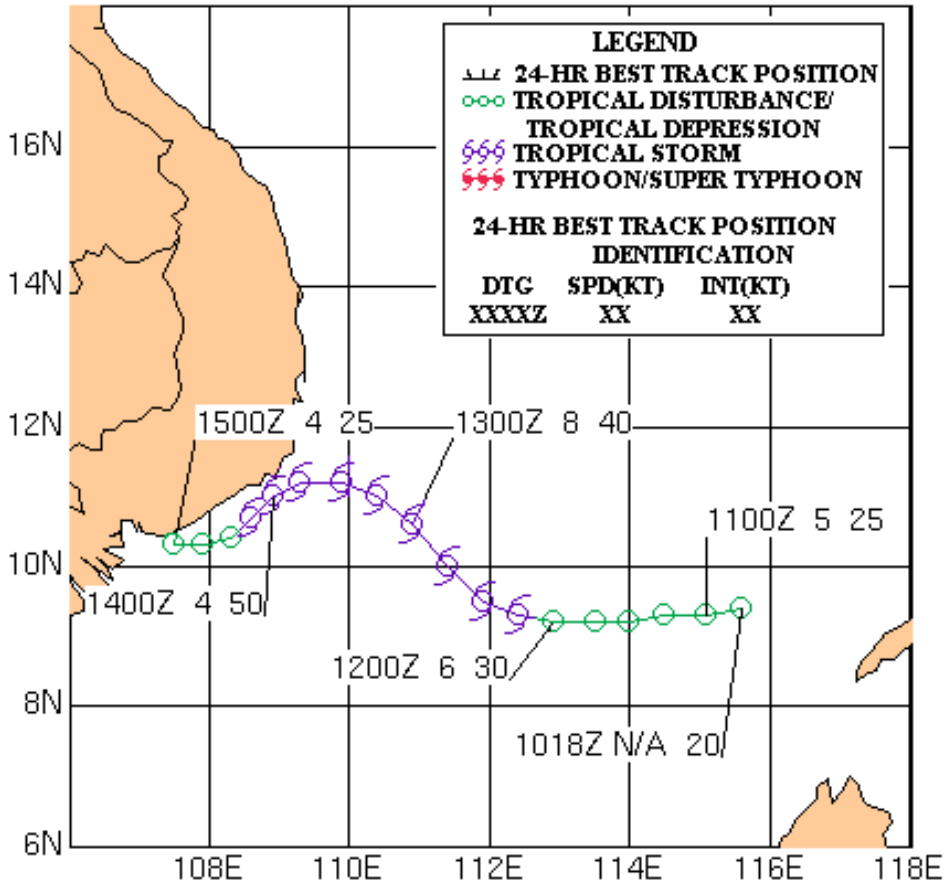
TD 21W tracked slowly northwestward toward Vietnam, and reached tropical storm intensity at 120600Z November. TS Chip reached a maximum intensity of 50 kt at 131200Z November. As TS Chip moved closer to southern Vietnam the effects of the land interaction and vertical wind shear began to weaken it. TS Chip then turned south and moved along the coast of southern Vietnam, as it continued to weaken. The final warning was issued at 150300Z.


SATELLITE: g5 98 11 12 2332Z INFRARED
WARNING: CHIP (21W) 981112 1800 10.1N 111.4E
NRL Monterey Code 7541
16N
12N
8N
4N
108E
112E
116E
-100 -90 -80 -70 -60 -50 -40 -30 -20 -10


SATELLITE: g5 98 11 12 2332Z VISIBLE
WARNING: CHIP (21W) 981112 1800 10.1N 111.4E
NRL Monterey Code 7541
16N
12N
8N
4N
108E
112E
116E


SATELLITE: f11 1998 11 13 0000Z PCT (Corrected Brightness Tempera
WARNING: CHIP (21W) 981112 1800 10.1N 111.4E
NRL Monterey Code 7541
12N
8N
4N
180 200 220 240 260 280


SATELLITE: f11 1998 11 13 0000Z 3-color combination
WARNING: CHIP (21W) 981112 1800 10.1N 111.4E
NRL Monterey Code 7541
16N
12N
8N
4N


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
16N
14N
12N
10N
8N
6N
108E
110E
112E
114E
116E
118E
1500Z 4 25
1300Z 8 40
1100Z 5 25
1400Z 4 50
1200Z 6 30
1018Z N/A 20

Tropical Storm Dawn (22W)

TS Dawn (22W) formed in the South China Sea, moved west, then northwest under the steering influence of the subtropical ridge. Three days later, TS Dawn (22W) dissipated over northern Cambodia.

Initially detected as a tropical disturbance on the 17th, a TCFA was issued at 180030Z November. The first warning on TS Dawn was issued at 180900Z after meteorological satellite data indicated an intensity of 25 kt.

TS Dawn moved northwest, away from an area of strong vertical wind shear and reached tropical storm intensity at 181800Z November. TS Dawn continued to move northwestward, and reached a maximum intensity of 45 kt before making landfall near Cam Ranh, Vietnam at 191500Z November. TS Dawn dissipated over northern Cambodia on 20 November.

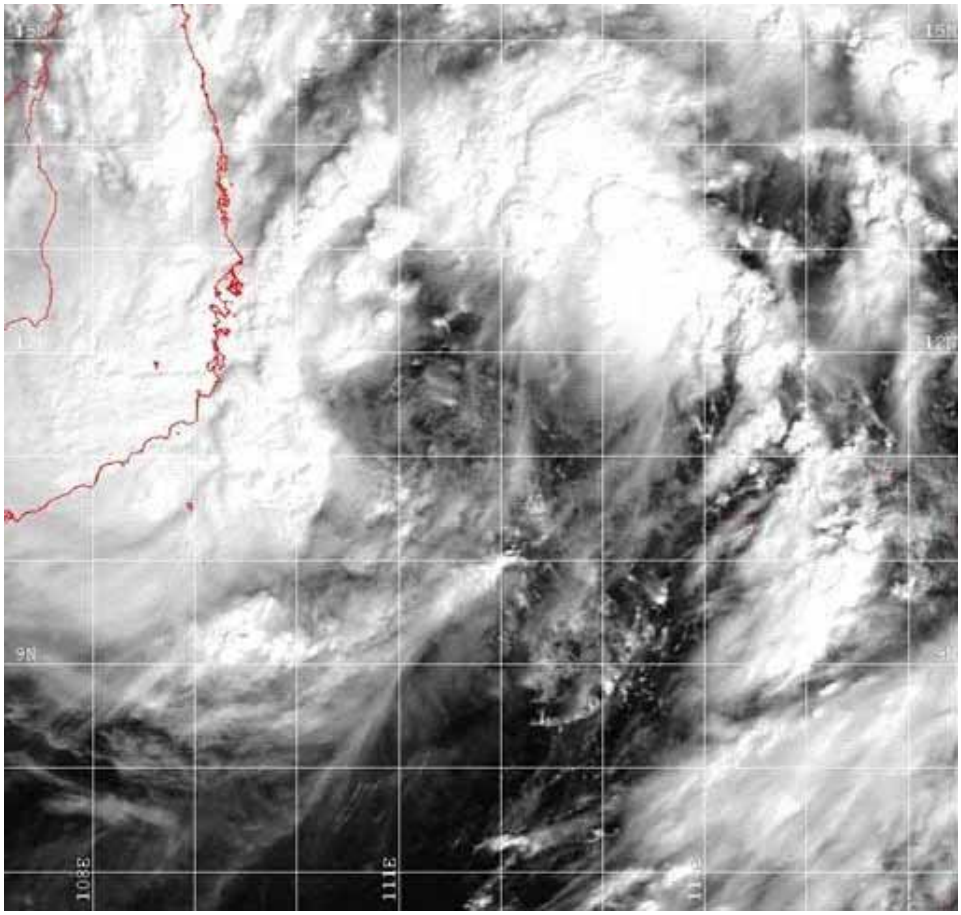
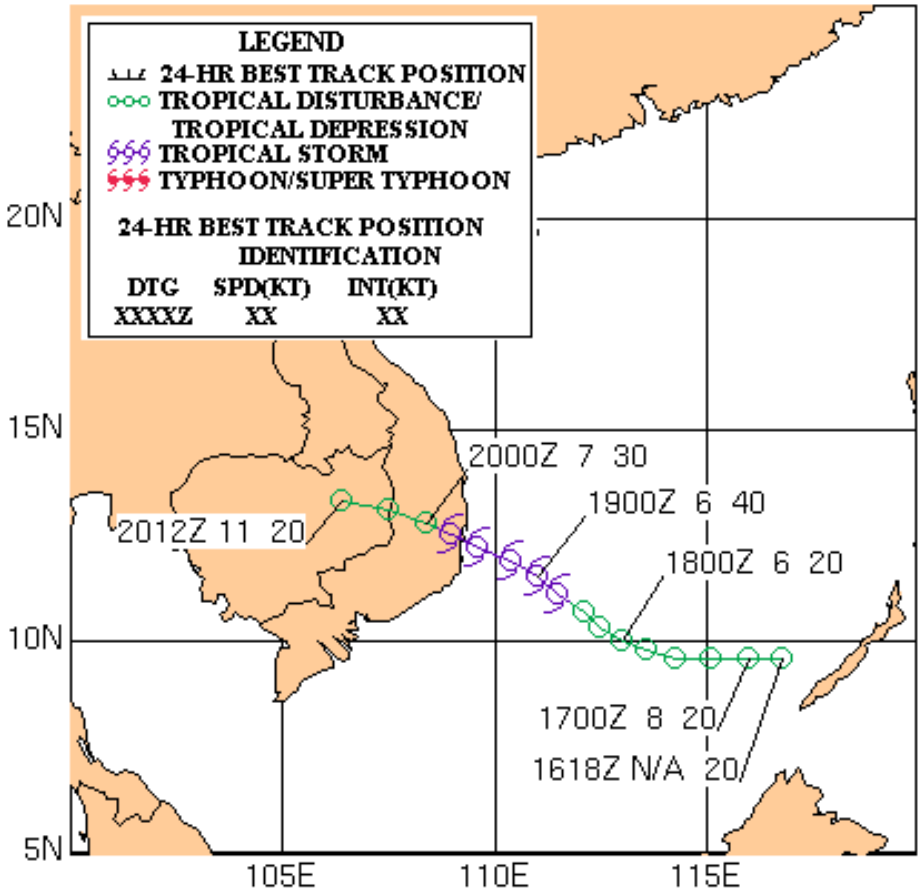


Figure 3-22-1. Visual image of TS Dawn (22W) before landfall with estimated winds of 40 kt. The cyclone would intensify to 45 kt before making landfall in central Vietnam.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
20N
15N
10N
5N
105E
110E
115E
2000Z 7 30
1900Z 6 40
1800Z 6 20
2012Z 11 20
1700Z 8 20
1618Z N/A 20

Tropical Storm Elvis (23W)

TS Elvis (23W) was one of 10 tropical cyclones to form in the South China Sea during 1998, roughly twice the number expected (based on JTWC 15 year statistics). A straight-running cyclone, TS Elvis (23W), made landfall in Vietnam causing 49 deaths and flooding damage.

A TCFA was initially issued at 232300Z November for a poorly defined tropical cyclone with the strongest winds on the periphery. The first warning was issued at 240300Z November as ship reports and intensity estimates from satellite data indicated a 25 kt tropical cyclone. The cyclone began tracking west-northwest at 8 kt and reached tropical storm intensity at 241200Z November.

The system continued to move west-northwestward and attained a maximum intensity of 45 kt at 250000Z November. Moderate vertical wind shear prevented further intensification of TS Elvis (23W), which remained at 45 kt until making landfall at 252300Z November. The cyclone moved onshore north of Quy Nhon, Vietnam and dissipated after 12 hours. The final JTWC warning was issued at 260900Z November.

According to reports compiled by the Dartmouth Flood Observatory, Dartmouth College, Hanover, NH, approximately 49 fatalities and 30 million U. S. dollars worth of damage in the Binh Dinh and Quang Ngai provinces of Vietnam resulted from the passage of TS Elvis (23W) and its associated rainfall and flooding.

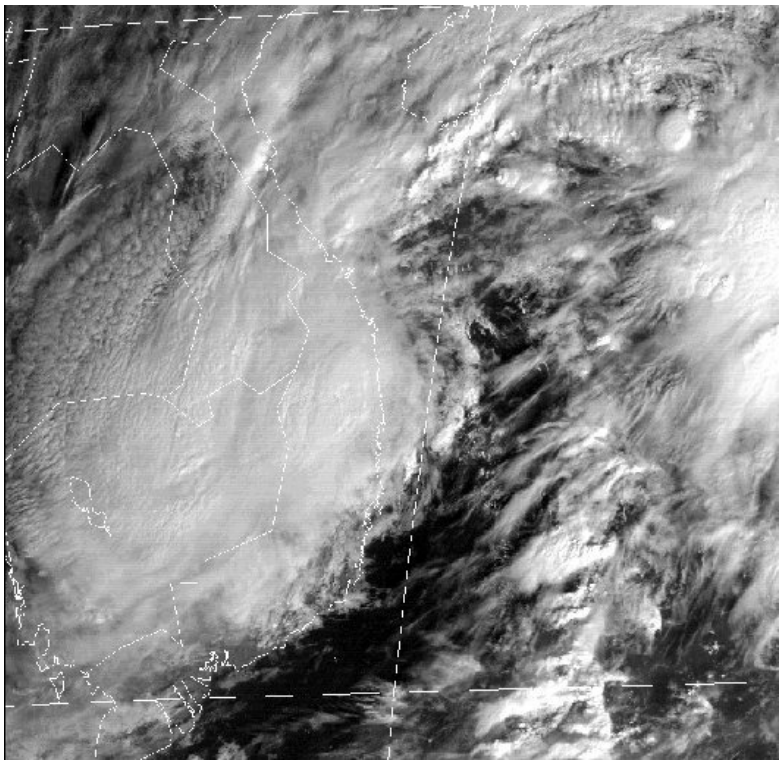
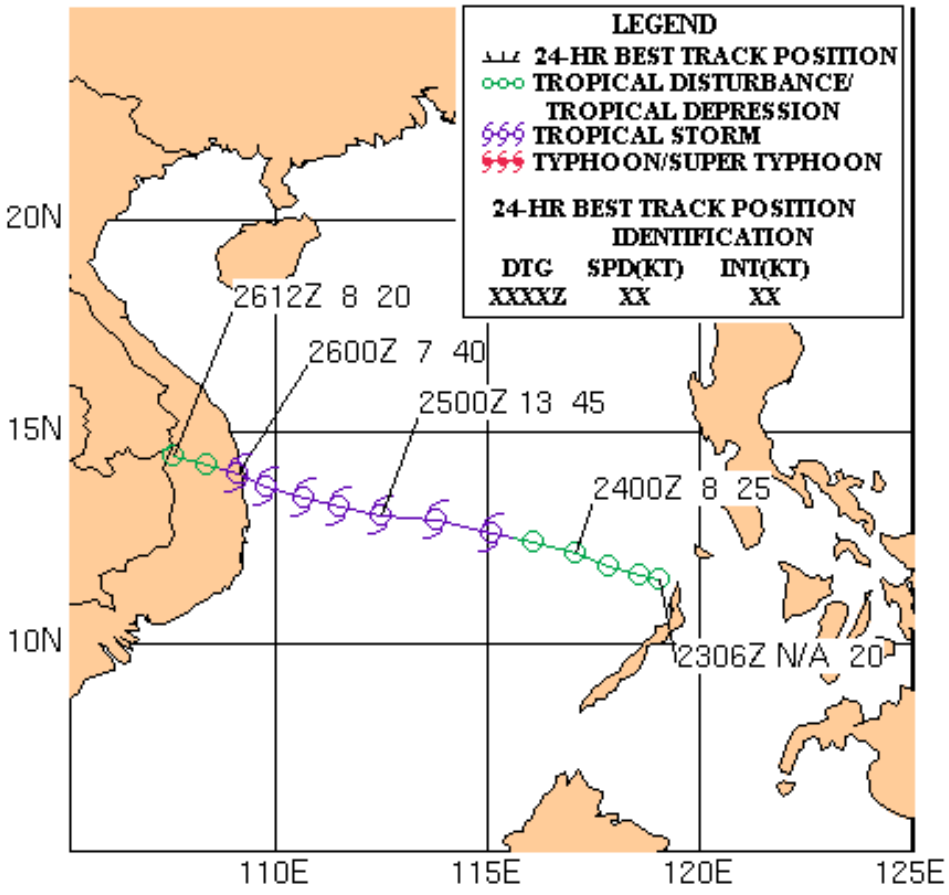


Figure 3-23-1. Visible satellite imagery of TS Elvis just after passing over the Vietnam coast.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
2612Z 8 20
2600Z 7 40
2500Z 13 45
2400Z 8 25
2306Z N/A 20
20N
15N
10N
110E
115E
120E
125E

Typhoon Faith (24W)

Typhoon Faith (24W) formed in the western Caroline Islands, developed into a significant tropical cyclone in the Philippine Sea, and reached typhoon intensity over Samar Island, Philippines. TY Faith (24W) continued to track westward and attained a maximum intensity of 90 kt in the South China Sea. As it continued west, it weakened and made landfall over central Vietnam as a tropical storm.

A Tropical Cyclone Formation Alert was first issued at 080330Z December, when the disturbance was located south of Sorol Atoll, Federated States of Micronesia. The first warning was issued at 080900Z December as conventional infrared, visual, and microwave satellite data and synoptic reports indicated a 25 kt intensity. The first warning forecast rapid (12-18 kt) west-northwest movement and slow intensification.

At 090000Z, TD 24W headed northwestward in response to a weak mid-latitude trough that passed north of the cyclone in the mid-tropospheric westerlies. TD 24W then resumed a westward track toward the central Philippines and was upgraded to TS Faith (24W) at 091800Z December.

Six hours prior to the landfall over Samar Island, the cyclone took another short jog to the northwest in response to a second weak passing mid latitude trough, but again resumed a more westward heading after the trough had passed to the northeast.

TS Faith attained typhoon intensity at 101200Z December while passing over the Philippine island of Samar. TY Faith continued across the central Philippine Islands while maintaining minimal typhoon intensity.

Over the South China Sea, TY Faith intensified while moving west-southwestward at 14 to 18 kt. The cyclone attained a maximum intensity of 90 kt at 111200Z December and maintained this intensity while slowing during the next 24 hours. TY Faith (24W) made a second landfall over Vietnam at 140000Z December near Cam Ranh, Vietnam. The cyclone quickly weakened as it moved inland into central Vietnam and the final warning was issued at 141500Z December.

At least 38 people were reported killed in Vietnam with over 10,000 evacuated due to flooding in low-lying areas. Damage assessments for Vietnam reached over $20 million.

Reports from the Philippines indicated 29 people were killed and over 20,000 were displaced due to the passage of TY Faith. The Philippine Navy rescued 100 people from a disabled ferry travelling from the Philippines to Malaysia. The damage estimate for the Philippines was over $13 million.

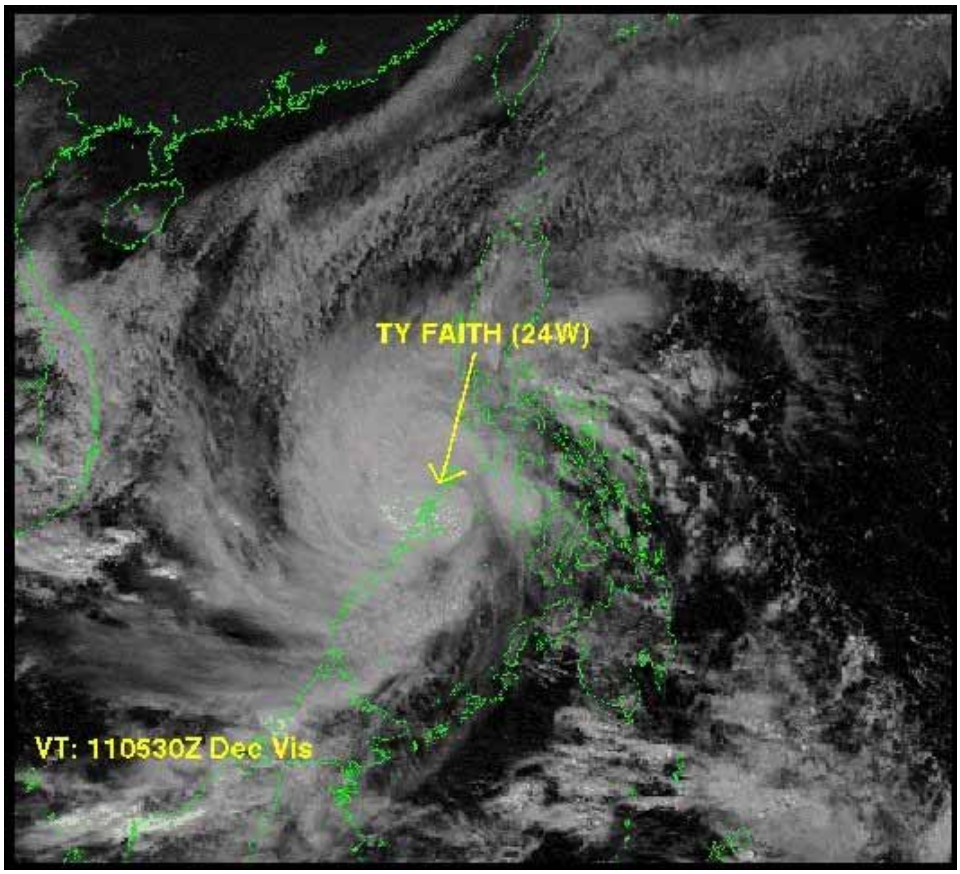
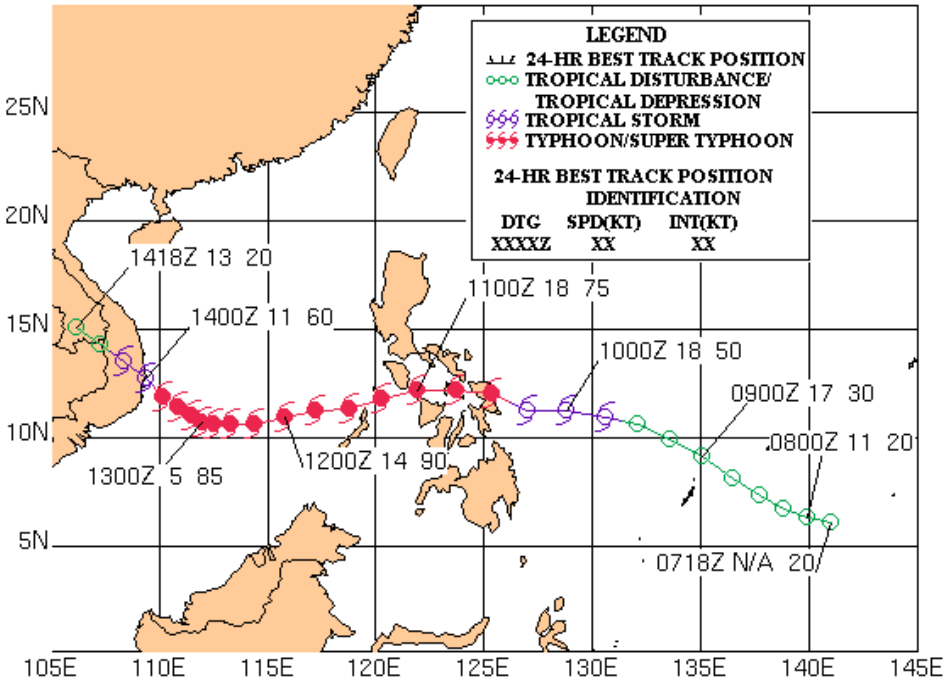


Figure 3-24-1. GMS-5 visible image of TY Faith as it moves into the South China Sea. TY Faith's intensity was 80 kt and it peaked at 90 kt six hours later.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
25N
20N
15N
10N
5N
105E
110E
115E
120E
125E
130E
135E
140E
145E
1418Z 13 20
1400Z 11 60
1100Z 18 75
1000Z 18 50
0900Z 17 30
0800Z 11 20
1300Z 5 85
1200Z 14 90
0718Z N/A 20

Tropical Storm Gil (25W):

Tropical Storm (TS) Gil (25W), began as a monsoon depression in the South China Sea, developed off the coast of north Borneo, slowly intensified and attained maximum winds of 35 kt while moving due west. It later dissipated over the Malay Peninsula.

A TCFA was issued at 090530Z December for an area of heavy convection and thunderstorm activity with numerous small cyclonic circulations. The first warning was issued at 091500Z December as satellite and synoptic data indicated consolidation and organization into a single cyclone.

TS Gil (25W) began moving west-northwest at 7 to 9 kt while slowly consolidating and intensifying. It reached tropical storm intensity on 101800Z December. Persistent vertical wind shear caused by mid to upper tropospheric southwesterlies and low to mid tropospheric easterlies and interaction with land inhibited further development.

TS Gil (25W) weakened to 30 kt at landfall over the Malay Peninsula near Songkhla, Thailand and rapidly dissipated. JTWC issued the final warning at 130300Z.

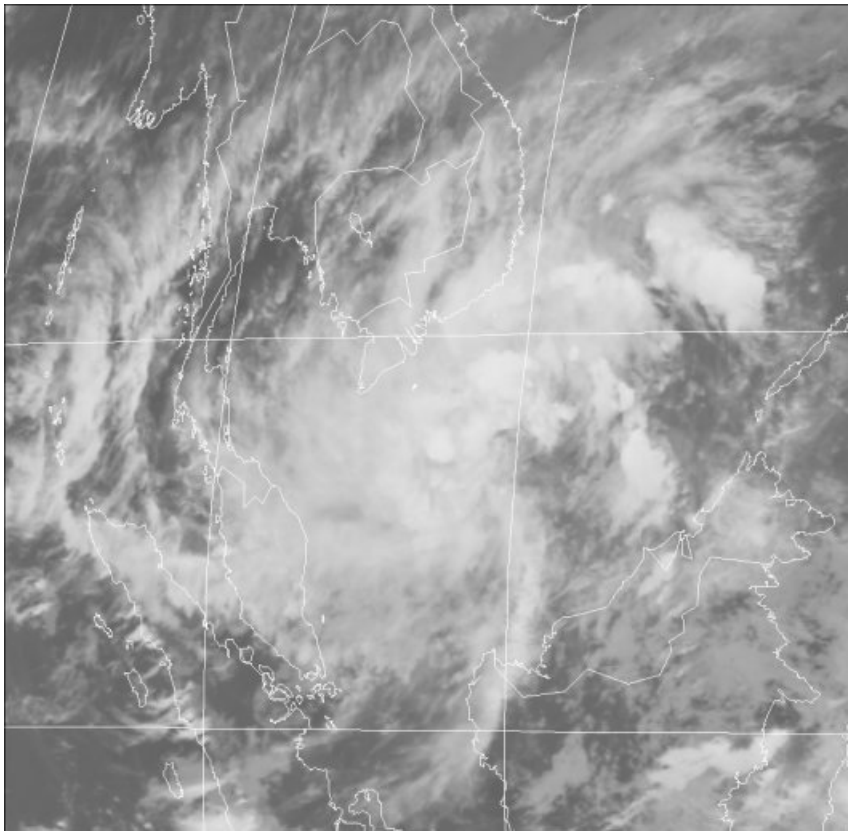
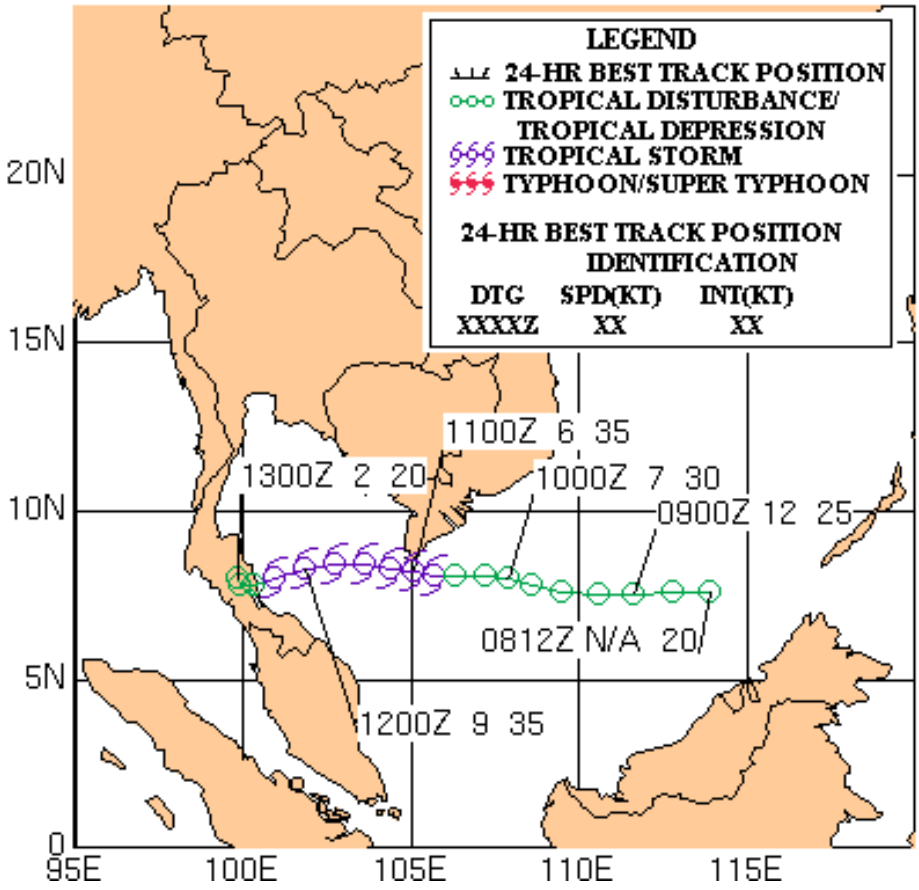


Figure 3-25-1. 091132Z December visible satellite image of TS Gil (25W) at initial warning time.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
20N
15N
10N
5N
0
95E
100E
105E
110E
115E
1100Z 6 35
1300Z 2 20
1000Z 7 30
0900Z 12 25
0812Z N/A 20
1200Z 9 35

Tropical Depression 26W

TD 26W began as a very large area of convection over the southern Philippines and tracked northward through the center of the country. The highest winds occurred on the periphery of the circulation, indicating a monsoon depression. A Tropical Cyclone Formation Alert was issued at 171100Z December and indicated numerous small circulations within a large area of convection. The first warning was issued at 171500Z December in the Sibuyan Sea.

TD 26W tracked west-northwestward at 12 to 16 kt and turned northward, passing over central Luzon and into the South China Sea just north of Lingayen Gulf. TD 26W failed to consolidate and intensify due to vertical shear and inflow disruption caused by the mountainous terrain of the Philippine Islands. The cyclone rapidly weakened during the transit over Luzon and the last warning was issued at 190300Z December.

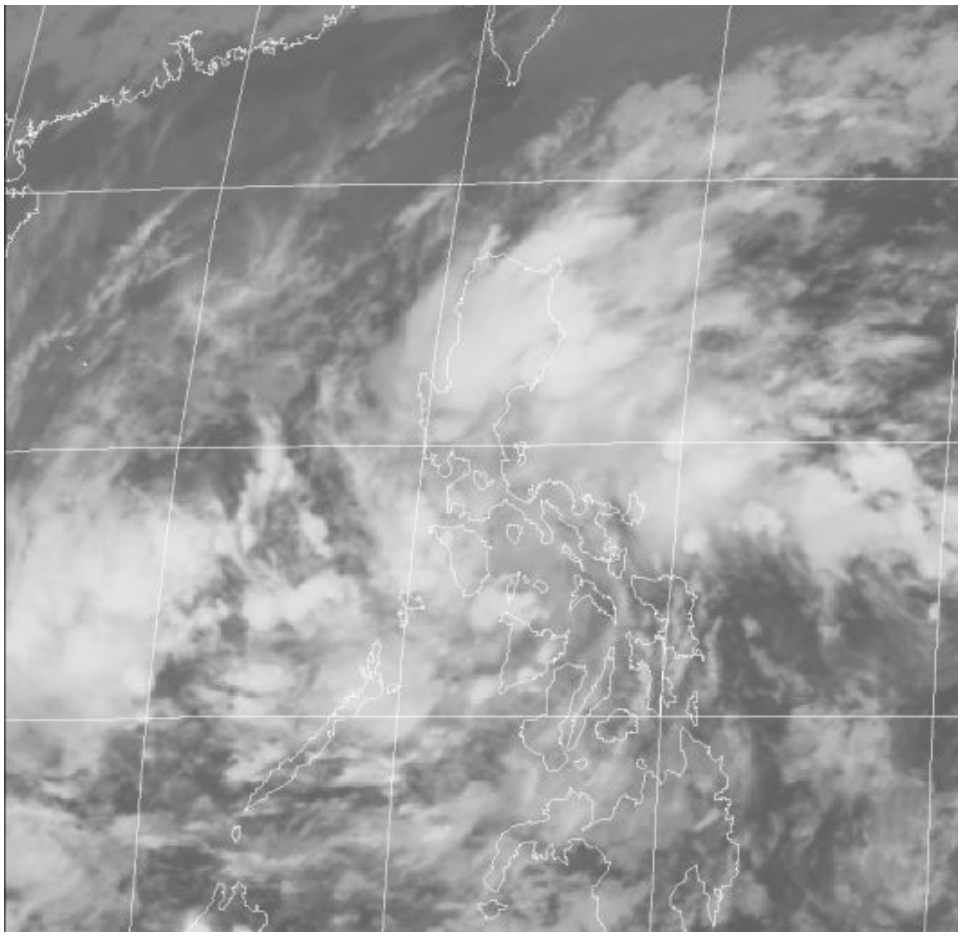
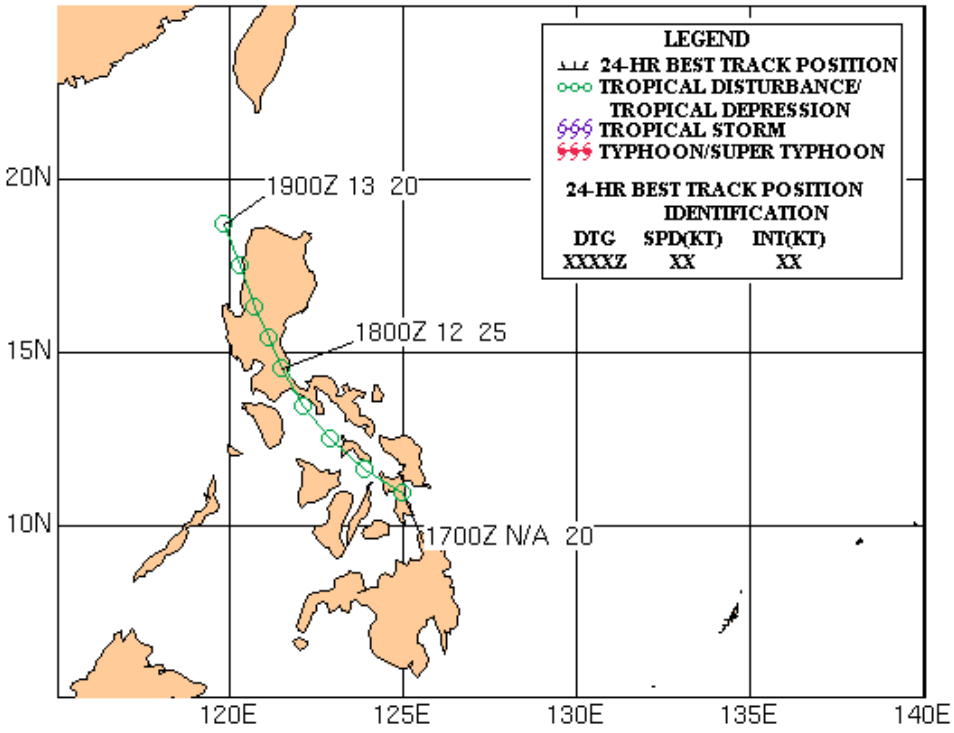


Figure 3-26-1. 171132Z December infrared satellite image with TD 26W located in the Sibuyan Sea.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
1900Z 13 20
1800Z 12 25
1700Z N/A 20
20N
15N
10N
120E
125E
130E
135E
140E

Tropical Depression 27W

TD 27W was a poorly organized tropical cyclone, which failed to develop due to unfavorable environmental conditions. This cyclone formed from a loosely organized cluster of convection in the central South China Sea, with maximum winds along the periphery of the circulation. Like TD 26W, TD 27W experienced a slight increase in organization and then a steady state with a 30 kt intensity for about 24 hours, then weakened and dissipated in the South China Sea.

The first warning was issued at 190900Z December and forecast northwest movement toward Vietnam with maximum winds of 40 kt. The cyclone drifted north to northeastward at 3 to 6 kt during the first 18 hours. TD 27W had a poorly defined low-level circulation center with disorganized convection and subsequently failed to consolidate and organize any further. During this initial period, the cyclone accelerated slightly on the northeastward track while maintaining a 30-knot intensity. The cyclone turned more east-northeastward and weakened as it moved into a greater vertical wind shear environment associated with strong mid to upper tropospheric westerly flow. JTWC issued the final warning at 220300Z December as the cyclone dissipated in the South China Sea just south of Pratas Island.

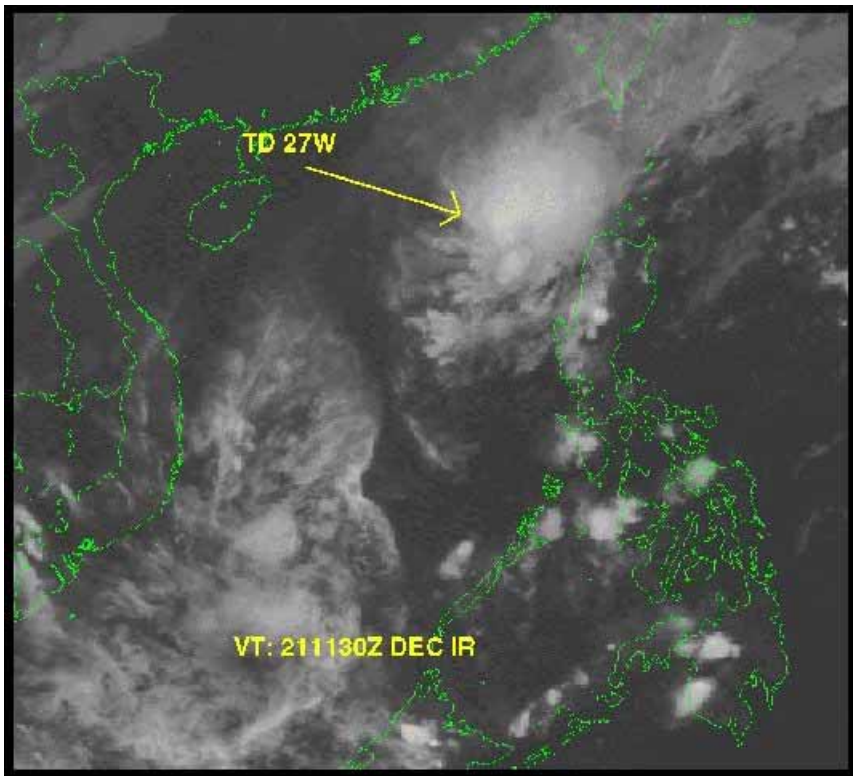
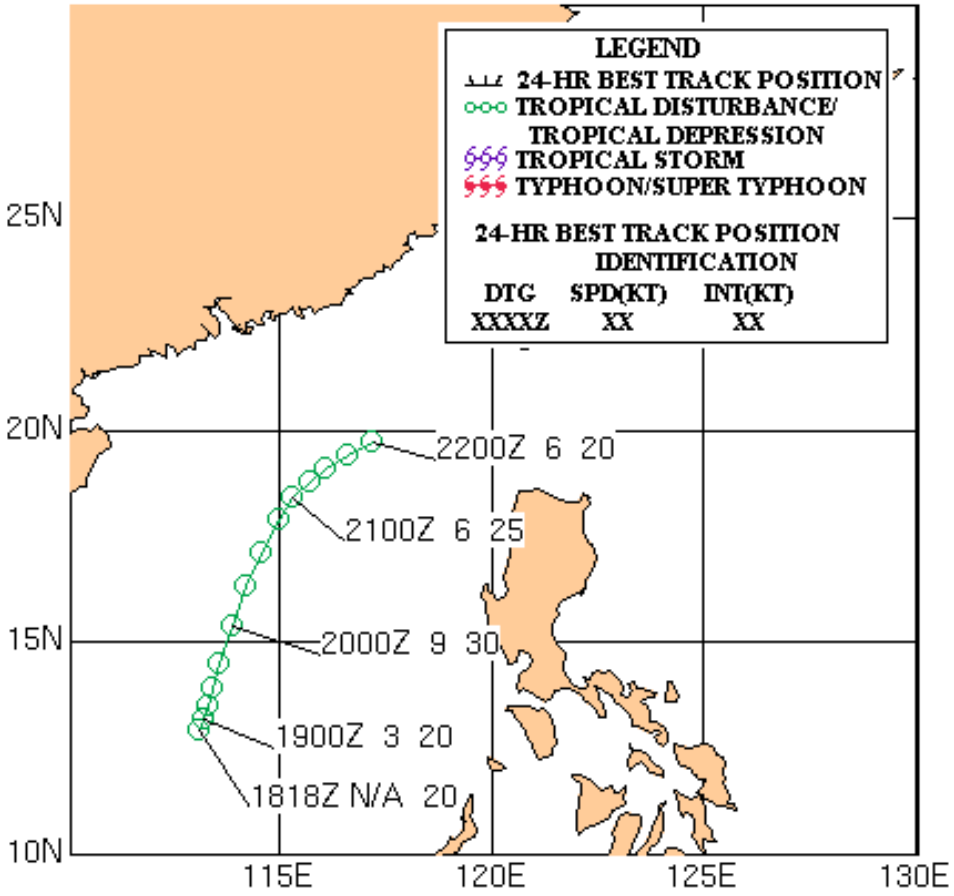


Figure 3-27-1. 211130Z December infrared satellite imagery depicting TD 27W about 12 hours prior to final warning.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
25N
20N
15N
10N
115E
120E
125E
130E
2200Z 6 20
2100Z 6 25
2000Z 9 30
1900Z 3 20
1818Z N/A 20

Tropical Cyclone 01B

The first North Indian Ocean tropical cyclone, TC (01B), of 1998 developed in the southern Bay of Bengal in mid May. The weak tropical disturbance tracked toward southern India before turning northeastward toward Bangladesh. The disturbance reached tropical cyclone strength and peaked at 70 kt just before landfall in Bangladesh.

TC 01B developed from a weak, broad circulation in the near-equatorial trough southeast of Sri Lanka, India on 18 May. The cyclone moved northward for 24 hours, before turning westward toward the northern tip of Sri Lanka. As the cyclone became more organized, it moved northeastward toward Bangladesh. A TCFA was issued at 171600Z May and the first warning was issued at 180900Z May. The cyclone reached a maximum intensity of 70 kt at 200000Z May, just prior to landfall near Chittagong, Bangladesh.

The Associated Press reported that TC 01B ravaged the low-lying Bangladesh coast killing at least 12 people and destroying thousands of homes. A Chittagong Port Authority official reported a fully loaded oil tanker was damaged in a collision with another ship in the storm. A fishing boat and trawler were also caught in the high winds and seas and capsized.

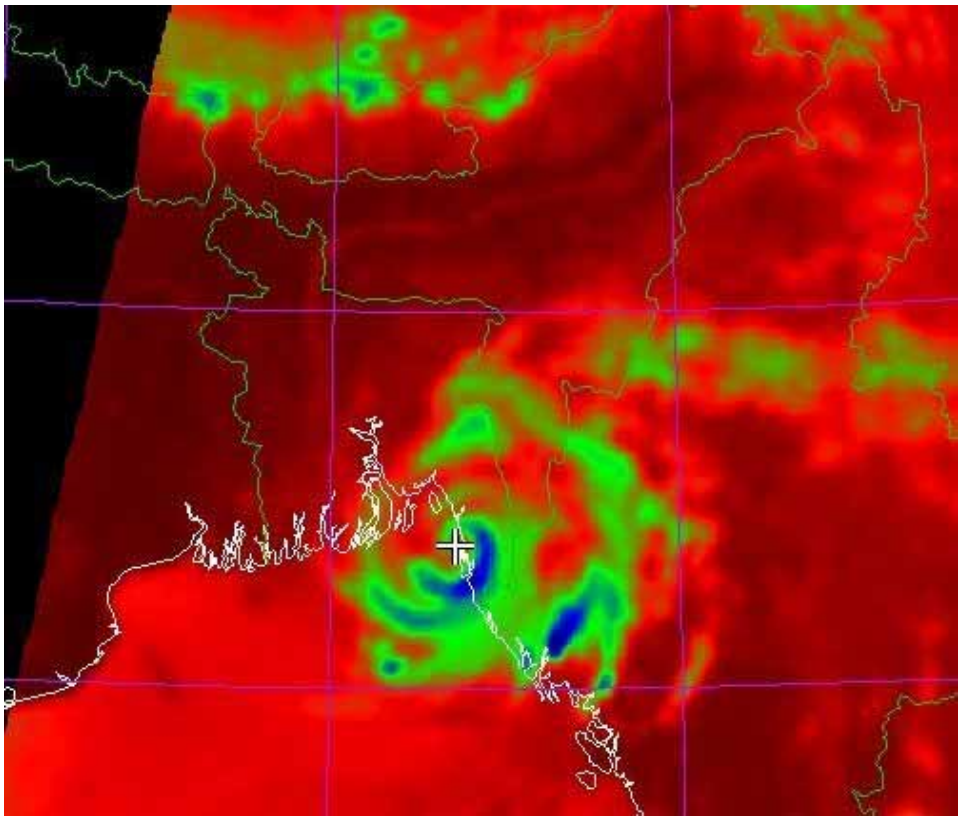
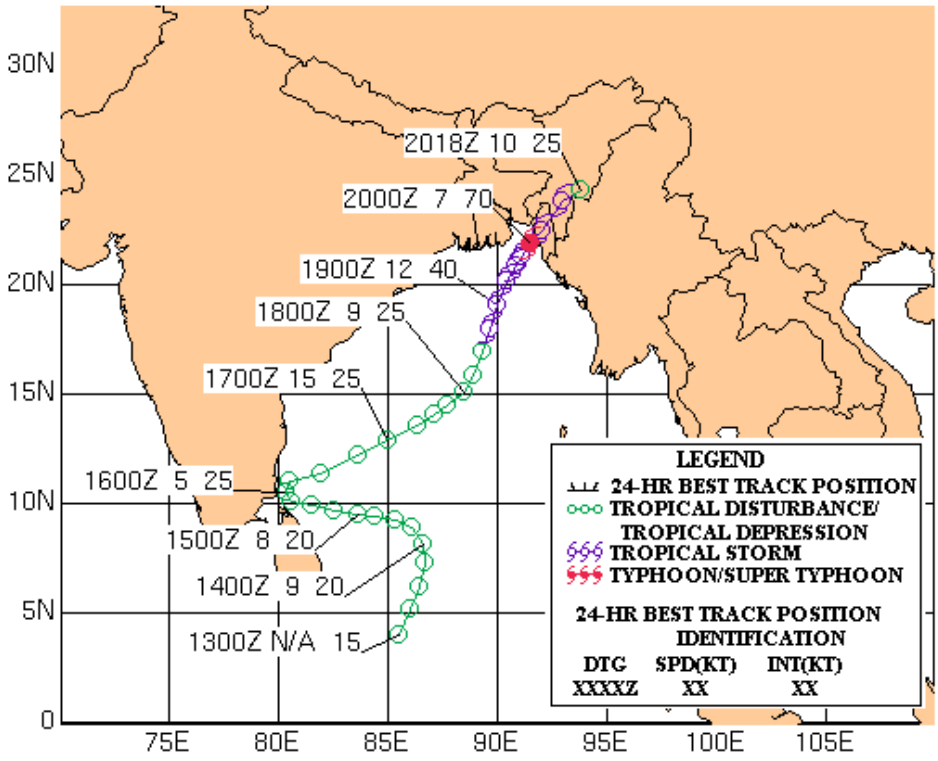


Figure 3-01B-1. 85 GHz SSM/i image at 200113Z May as TC 01B made landfall at its max intensity.


30N
25N
20N
15N
10N
5N
0
75E
80E
85E
90E
95E
100E
105E
2018Z 10 25
2000Z 7 70
1900Z 12 40
1800Z 9 25
1700Z 15 25
1600Z 5 25
1500Z 8 20
1400Z 9 20
1300Z N/A 15
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX

Tropical Cyclone 02A

TC 02A was a short-lived tropical cyclone that developed in the Arabian Sea in late May. This cyclone existed for about 48 hours and during that period reached a maximum intensity of 35 kt while moving slowly toward the west-northwest.

The first warning was issued at 280300Z May. Moderate vertical windshear in the Arabian Sea inhibited the system's development, which peaked at 35 kt. JTWC issued the final warning on this cyclone at 290300Z May as it dissipated over water.

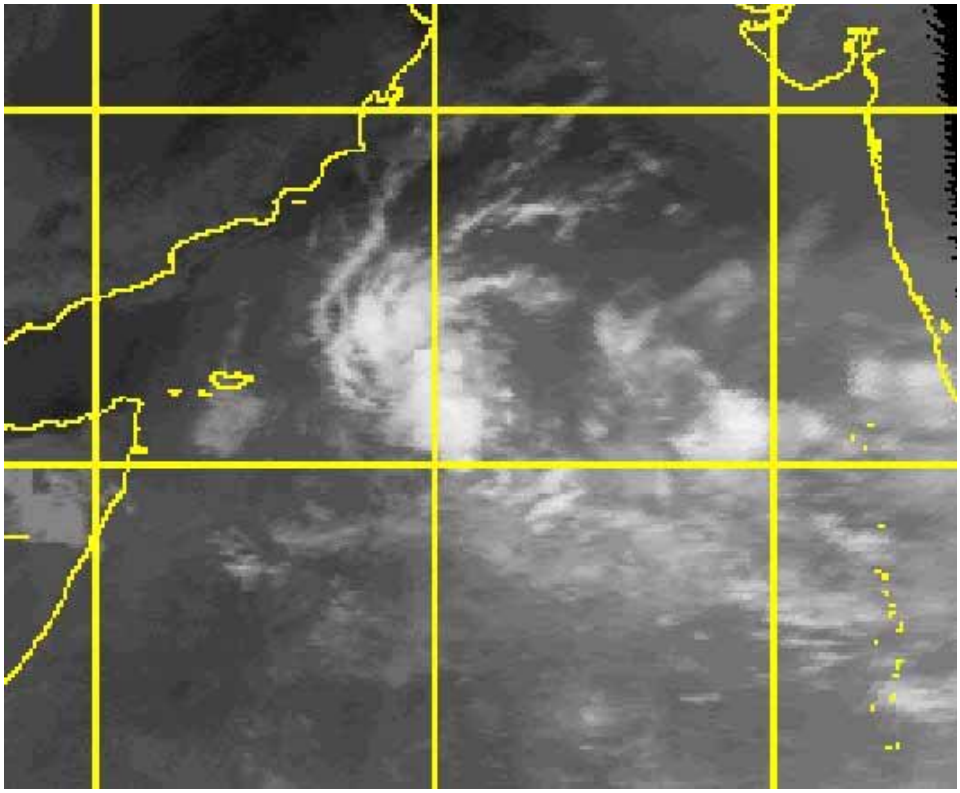
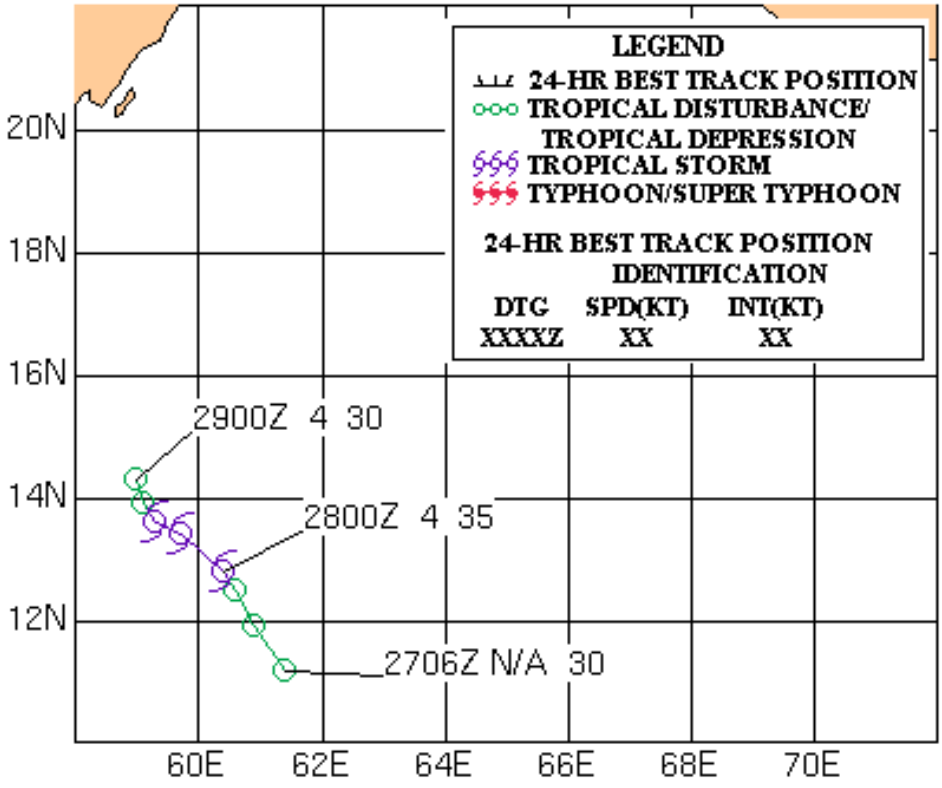


Figure 3-02A-1. Tropical Cyclone 02A undergoing vertical wind shear at its peak intensity of 35 kt. This Meteosat-5 infrared image is from 0300 on 28 May. The system dissipated over water within 24 hours of this image.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
20N
18N
16N
14N
12N
60E
62E
64E
66E
68E
70E
2900Z 4 30
2800Z 4 35
2706Z N/A 30

Tropical Cyclone 03A

Tropical Cyclone 03A, the most intense tropical cyclone to strike India in 25 years, formed off the southwest tip of India early in June. The storm tracked westward over the Arabian Sea, then turned north and moved inland near Porbandar, India. TC 03A attained a maximum intensity of 105 kt, just prior to making landfall.

JTWC issued a Tropical Cyclone Formation Alert at 030200Z June for an area of convection in the Lacadive Islands. This area of convection continued to organize, and JTWC issued the first warning on TC 03A at 040300Z June.

The cyclone initially tracked slowly west-northwestward away from the Indian coast in response to steering flow of a mid-level ridge located to the northeast. TC 03A accelerated and moved more northward in response to an approaching mid-level trough. The altered synoptic pattern enhanced the outflow from TC 03A and the cyclone intensified and reached maximum intensity of 105 kt as it turned north-northeastward toward India.

TC 03A made landfall in India's western state of Gujarat at 090130Z June. JTWC issued the final warning at 091500Z June due to rapid dissipation over land.

The damage caused by the most intense tropical cyclone to strike India in 25 years was extensive. The NASA sponsored Dartmouth Flood Observatory reported 1126 fatalities in the Guarat, Kutch, Surashtra regions of India with heavy flooding of coastal highways. Homes near the Kandla port were submerged by a two meter tidal wave. The Dartmouth Flood Observatory further reported the drowning of many salt workers in these regions. Over 15,000 people were dislocated as thousands of houses were damaged or destroyed. Total damage estimates were nearly 290 million dollars.

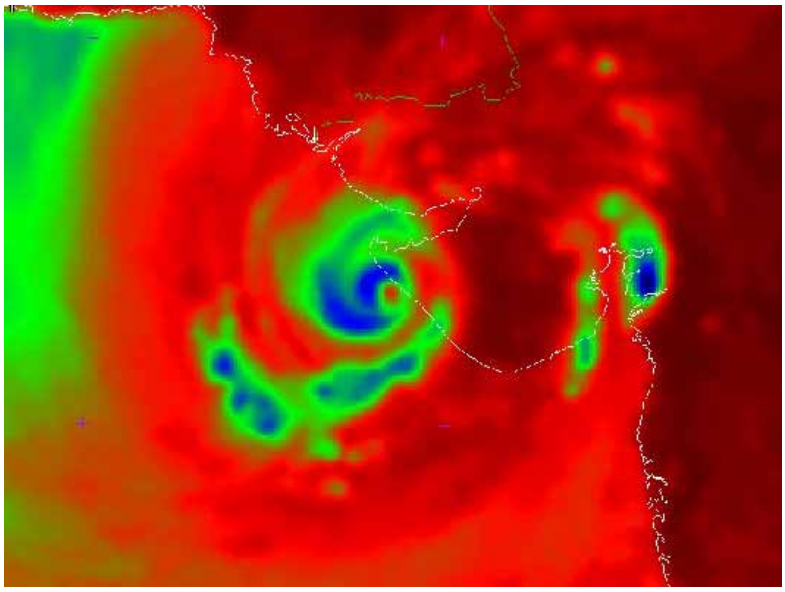


Figure 3-03A-1. An 0137Z Special Sensor Microwave Imager depiction of TC 03A as it made landfall over India as a 105 kt system on the 9th of June, 1998.

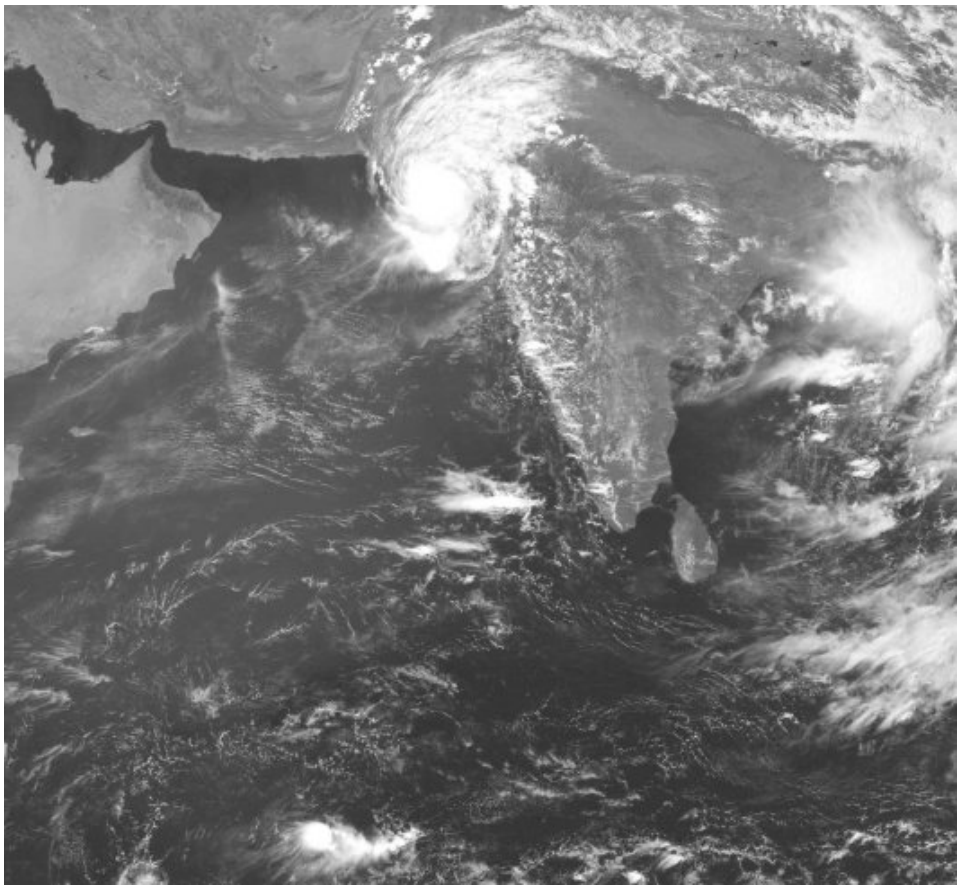
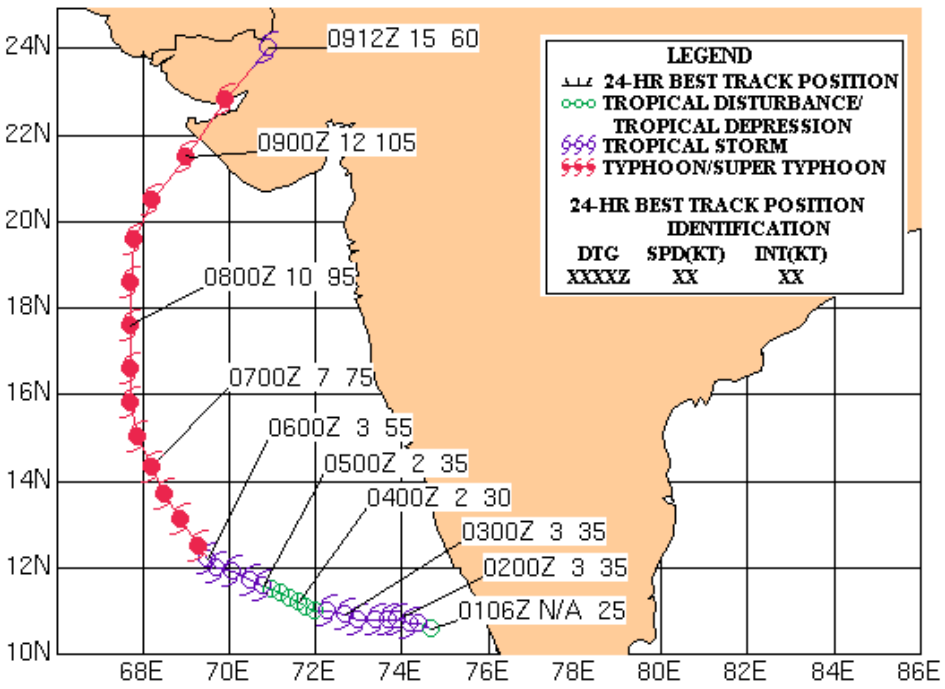


Figure 3-03A-2. An 0900Z visible satellite image of TC 03A just making landfall in Northwestern India on the 9th of June, 1998.


0912Z 15 60
0900Z 12 105
0800Z 10 95
0700Z 7 75
0600Z 3 55
0500Z 2 35
0400Z 2 30
0300Z 3 35
0200Z 3 35
0106Z N/A 25
LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/ TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
24N
22N
20N
18N
16N
14N
12N
10N
68E
70E
72E
74E
76E
78E
80E
82E
84E
86E

Tropical Cyclone 04A

Tropical Cyclone 04A was a short-lived system that developed in the Arabian Sea in late September, then tracked west and quickly dissipated after reaching a peak intensity of 35 kt.

Tropical Cyclone 04A formed in a east-west oriented surface trough in the Arabian Sea, 400 nm west of Bombay in late September. It moved slowly west while developing slowly within a moderate vertical wind shear environment.

JTWC issued the first warning at 300300Z September when the cyclone had a maximum intensity of 35 kt. After the first warning, TC 04A moved west at 10 kt under the steering influence of a mid-level ridge located to the north. TC 04A did not intensify beyond the initial warning intensity of 35 kt due to increased vertical wind shear. TC 04A weakened to 30 kt, and the final warning was issued at 010300Z October.

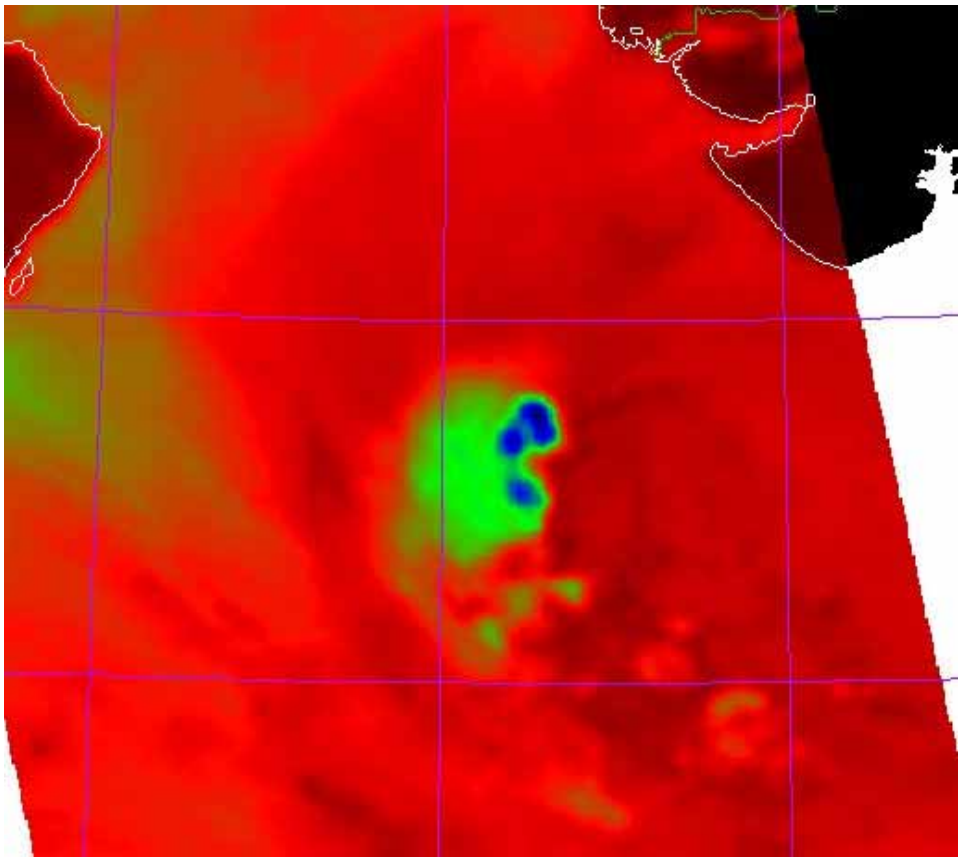


Figure 3-04A-1. 291444Z Special Sensor Microwave Imager depiction of TC 04A as it crossed the Arabian Sea on the 29th of September.

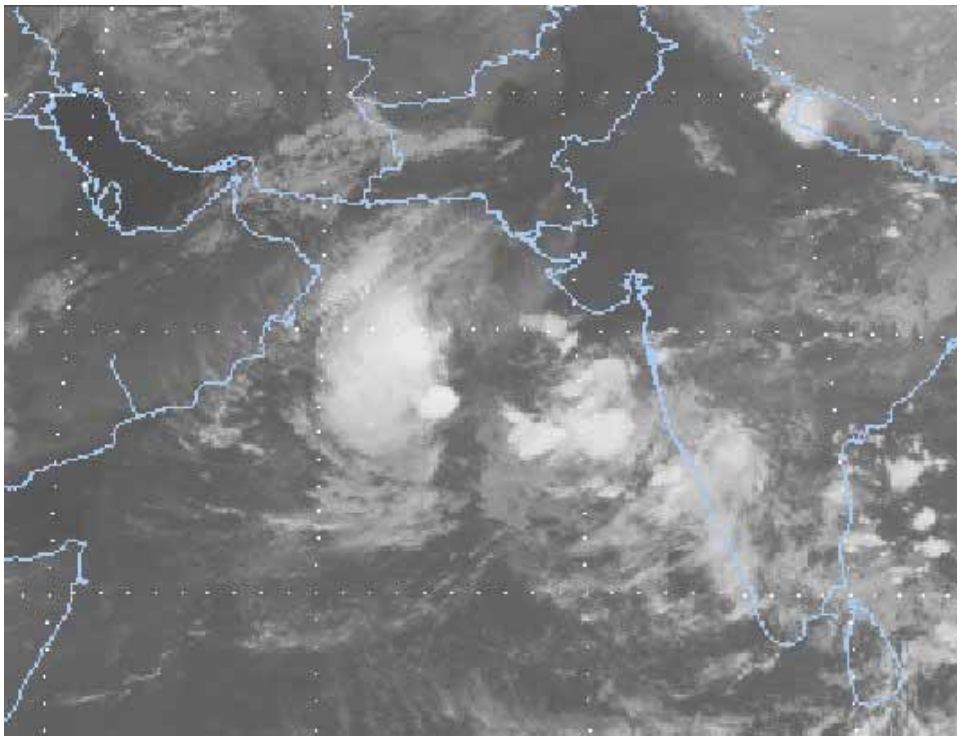
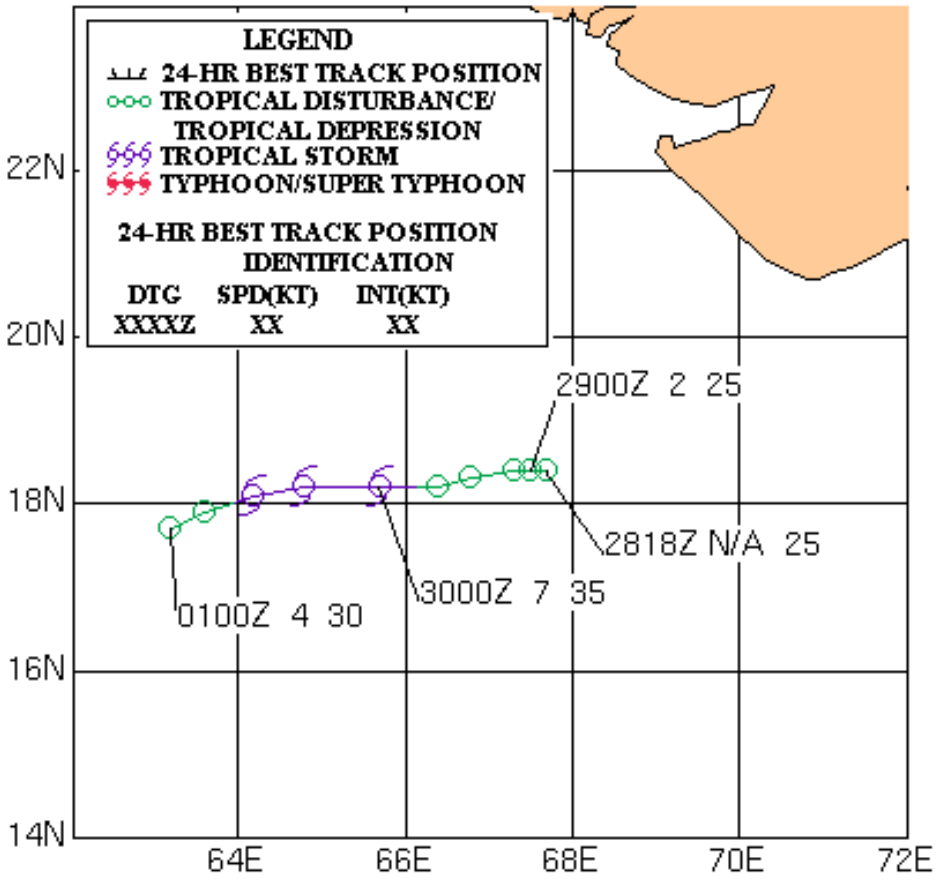


Figure 3-04A-2. A 300000Z September infrared satellite image of TC 04A at its maximum intensity of 35 kt.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
22N
20N
18N
16N
14N
64E
66E
68E
70E
72E
2900Z 2 25
2818Z N/A 25
3000Z 7 35
0100Z 4 30

Tropical Cyclone 05A

TC 05A formed in the Arabian Sea west of the Laccadive Islands in mid-October. The system tracked east, then northeast and made landfall at Gujarat, India as a 30 kt system. TC 05A was a minimal tropical cyclone with a peak intensity of 35 kt.

TC 05A began as a weak area of low pressure drifting slowly toward India. A TCFA was issued at 150900Z October, based on an ERS-2 scatterometer pass indicating 25 kt winds associated with the low-level circulation center. Despite moderate vertical wind shear limiting the organization of significant deep convection, JTWC issued the first warning at 160300Z October, based on a second scatterometer pass indicating winds of 35 kt.

Vertical wind shear over the tropical cyclone continued to inhibit further development as the system tracked northeast and accelerated slightly in response to environmental steering provided by mid-level ridging to the south. Although TC 05A was tracking toward the same area of India devastated in June by TC 03A, strong vertical wind shear dissipated most of the deep convection reducing the cyclone's intensity. Maximum sustained winds at landfall were 30 kt. JTWC issued its fifth and final warning at 180300Z October as the cyclone dissipated over land.

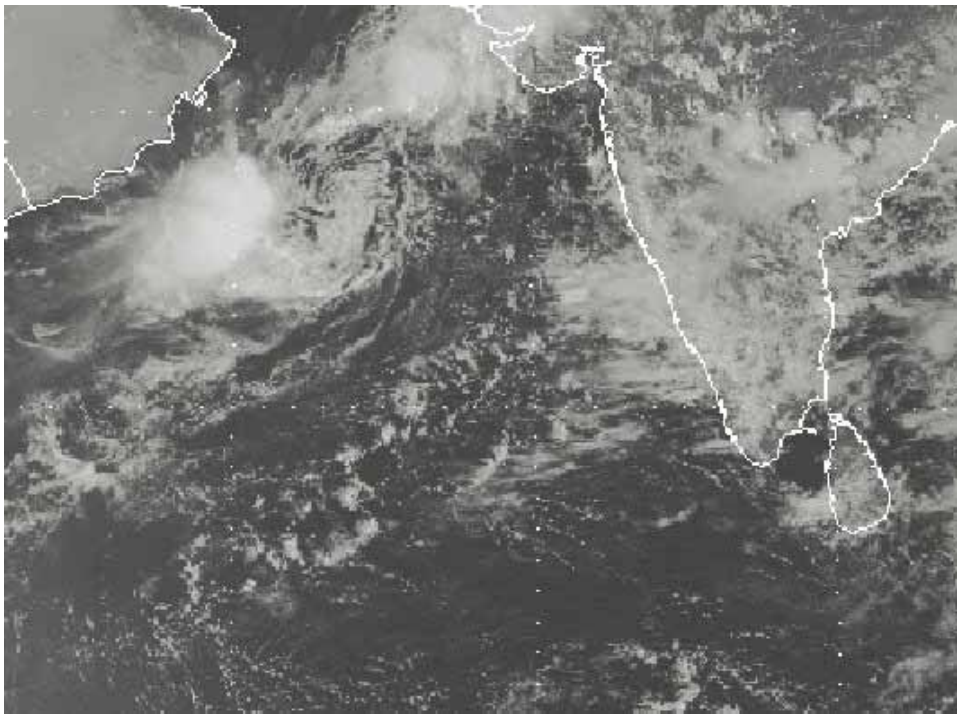


Figure 3-05A-1. An 100000Z Meteosat-5 visible image shows TC 05A under the influence of vertical wind shear on the 15th of October, 1998.

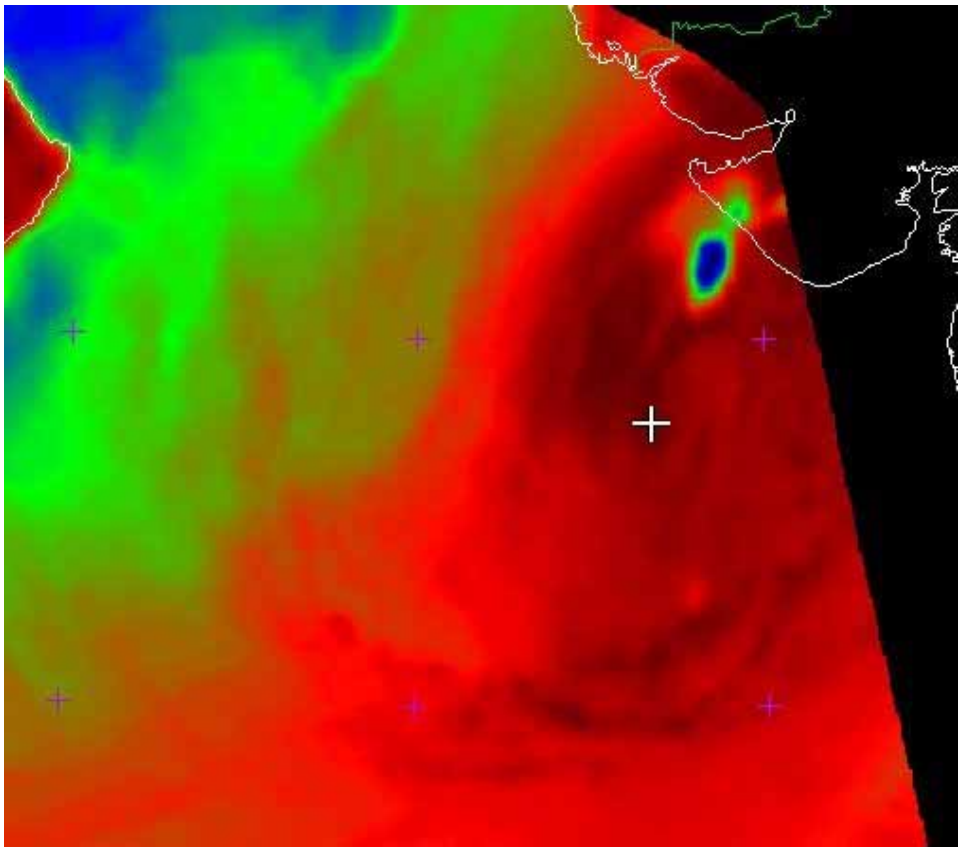
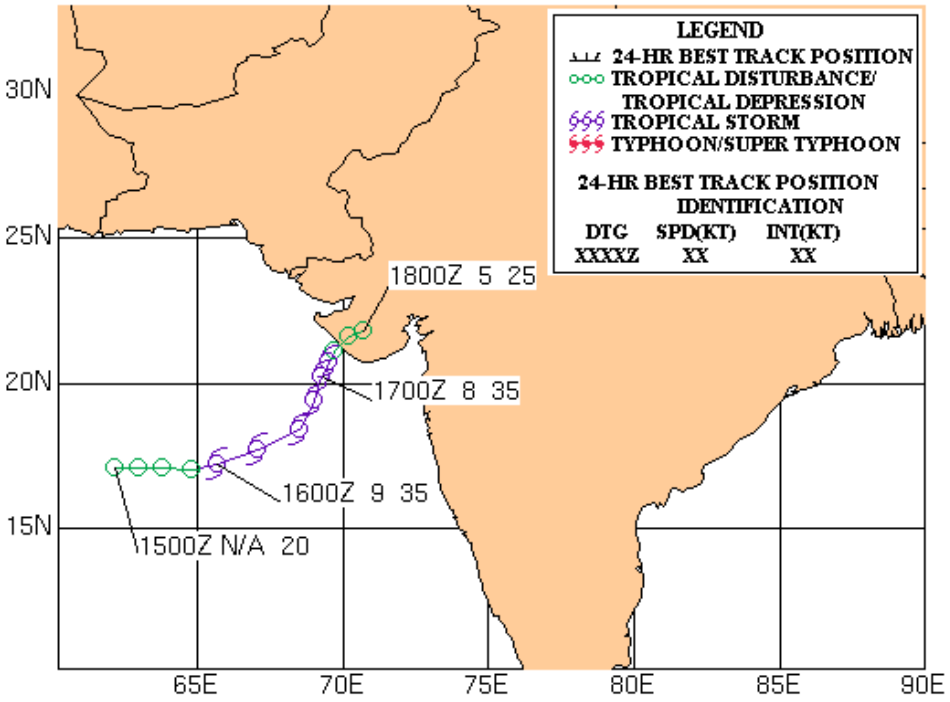


Figure 3-05A-2. A 130700Z microwave image of TC 05A southwest of the northwestern India on the 16th of October, 1998.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
30N
25N
20N
15N
65E
70E
75E
80E
85E
90E
1800Z 5 25
1700Z 8 35
1600Z 9 35
1500Z N/A 20

Tropical Cyclone 06B

Tropical Cyclone 06B formed in the Bay of Bengal in mid-November then tracked northwestward into east-central India and attained peak intensity of 85 kt just prior to landfall. The cyclone subsequently dissipated rapidly while moving north into central India.

A Tropical Cyclone Formation Alert was issued at 130630Z November. JTWC issued the first warning at 140300Z November as a 40 kt system.

TC 06B tracked steadily northwestward at speed of 8 to 13 knots while intensifying. The cyclone attained a maximum intensity of 85 knots at 151200Z November, just before making landfall 30 nm southwest of Visakhapatnam, India. TC 06B quickly dissipated over land and JTWC issued the final warning at 160300Z November.

According to RSMC Darwin's Monthly Report, TC 06B cause two deaths and extensive crop and property damage in India.

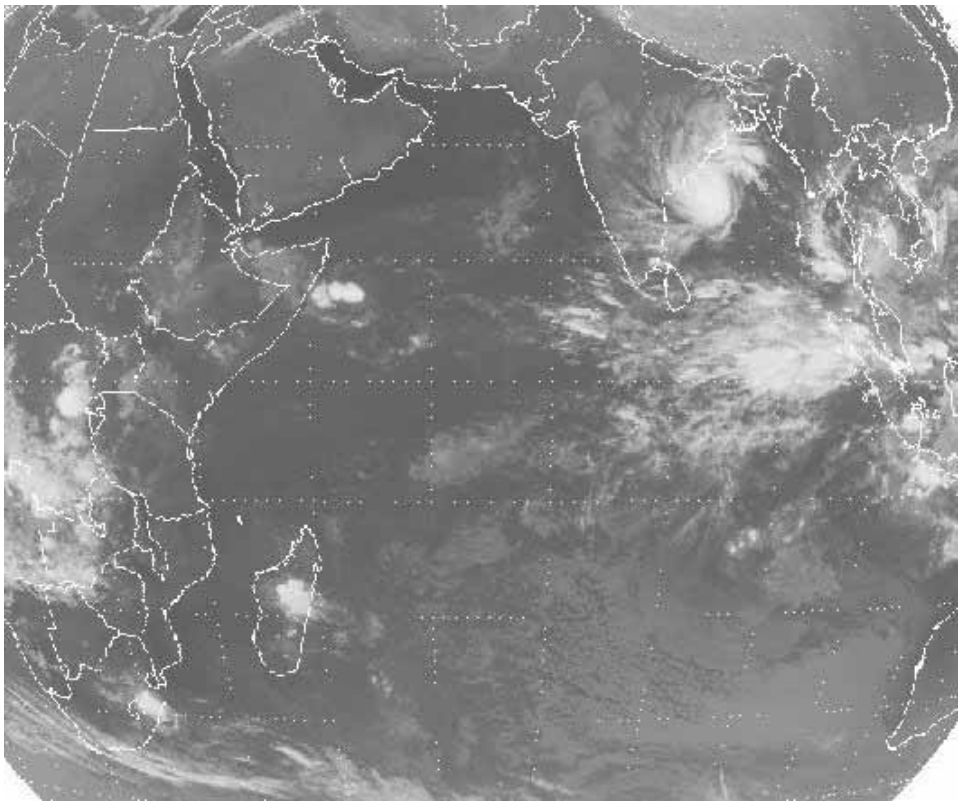
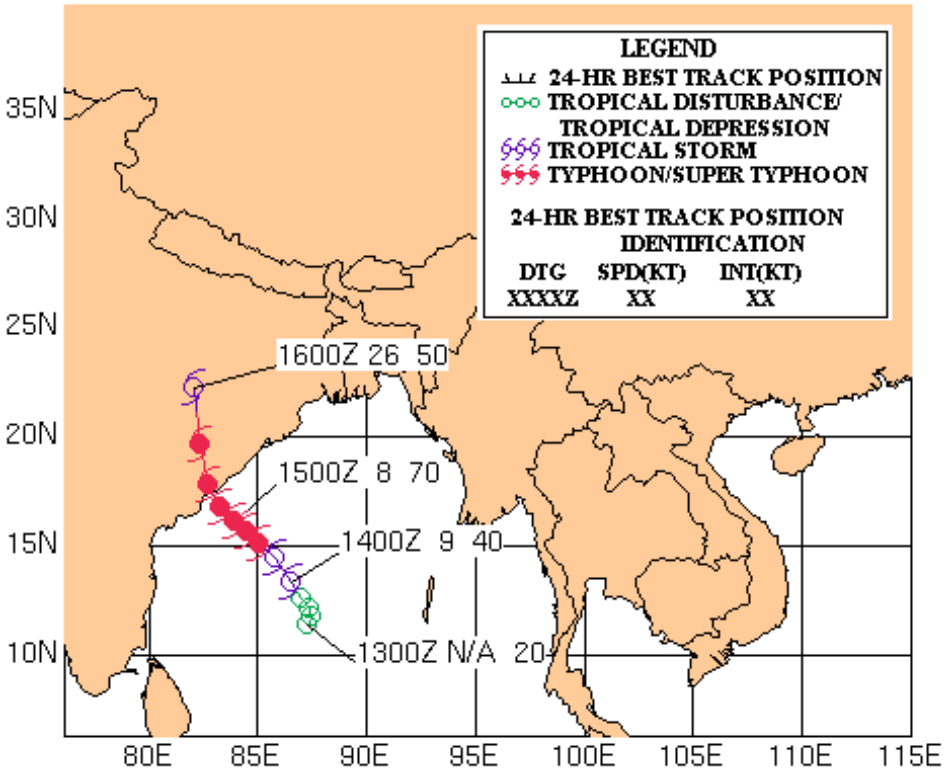


Figure 3-06B-1. Meteosat-5 depiction of TC 06B at 2030Z on the 14th of November, 1998 while TC 06B was a 70 kt system. TC 06B intensified to an 85 kt system within 12 hours.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
1600Z 26 50
1500Z 8 70
1400Z 9 40
1300Z N/A 20
35N
30N
25N
20N
15N
10N
80E
85E
90E
95E
100E
105E
110E
115E

Tropical Cyclone 07B

TC 07B formed from the remnants of TS Chip (21W). TS Chip dissipated over Vietnam on 15 November, and then tracked over Vietnam, into the Gulf of Thailand, westward across the Malay Peninsula, and into the Andaman Sea. As the remnants of TS Chip moved into the Bay of Bengal, JTWC began to issue warnings on this cyclone as TC 07B. TC 07B developed steadily in the Bay of Bengal, peaking at 75 kt on 220000Z November. TC 07B then weakened, making landfall in Bangladesh at minimal tropical storm intensity.

The first TCFA was issued on 180130Z November. Two more TCFA's were issued while the developing cyclone was under the influence of significant vertical windshear. The first warning was issued at 200300Z November with sustained winds of 35 kt. TC 07B initially tracked northwestward at 12 kt, briefly slowed to 5 kt, and then accelerated to 10 kt while intensifying. By 220000Z November, TC 07B reached a maximum intensity of 75 kt.

TC 07B began its turn northeastward as it moved along the western periphery of the subtropical ridge. During this northward movement, the vertical windshear increased dramatically, and weakened the system, displacing the deep convection to the northeast. TC 07B was a 35 kt system when it made landfall over Bangladesh (30 nm southwest of Bavisa). After making landfall, the cyclone dissipated and JTWC issued the final warning at 230300Z November.

The storm surge associated with TC 07B caused coastal communities in Bangladesh to be inundated. More than 100 fishermen were reported lost.

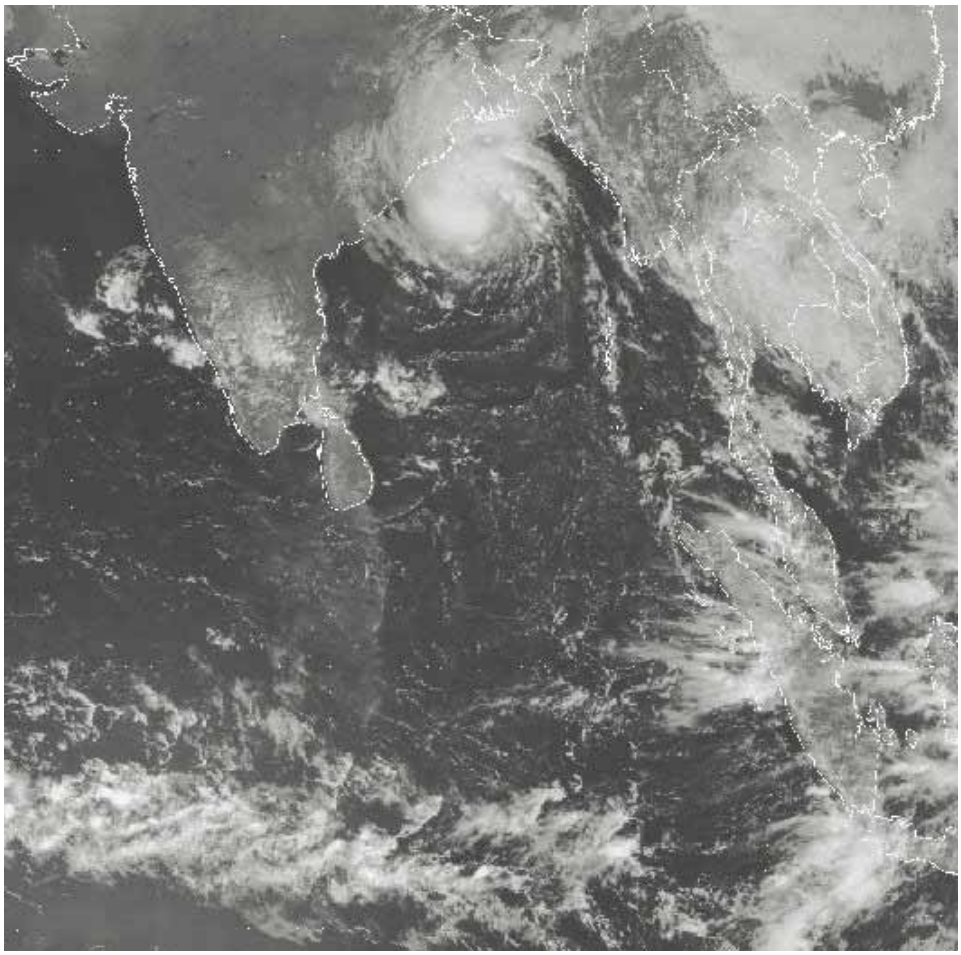
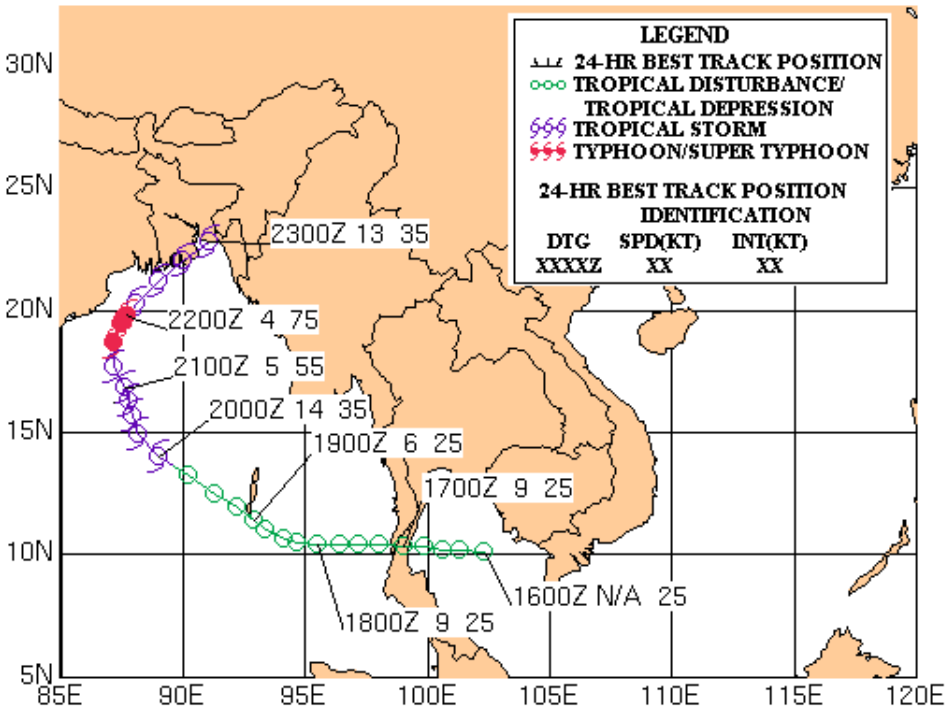


Figure 3-07B-1. Meteosat-5 visible imagery 210630Z November. TC 07B as a 60 kt system approaching the coast of India.


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
2300Z 13 35
2200Z 4 75
2100Z 5 55
2000Z 14 35
1900Z 6 25
1700Z 9 25
1600Z N/A 25
1800Z 9 25
30N
25N
20N
15N
10N
5N
85E
90E
95E
100E
105E
110E
115E
120E

Tropical Cyclone 08A

TC 08A developed slowly but attained a maximum intensity of 65 kt as it tracked across the Arabian Sea over a 6 day period before making landfall and dissipating over Oman.

TC 08A formed in the Laccadive Islands off the southwest tip of India in December. A TCFA was issued on 11 December and the first warning was issued at 130300Z December as the system drifted west-northwest at 3 kt.

On 131800Z December, TC 08A turned northward and accelerated as it continued to intensify. TC 08A reached its maximum intensity of 65 kt on 150600Z December, while tracking north-northwestward at 7 kt.

Dry air entrainment from the Arabian Peninsula and increased vertical wind shear weakened the cyclone. Subsequently, the convection was pushed to the northeast as the low-level circulation turned west on 160000Z December.

Although partially exposed, the low-level circulation remained tightly wound as TC 08A tracked westward. The cyclone made landfall in Oman at 170600Z December with maximum winds of 35 kt. After landfall, the cyclone rapidly weakened and the final warning was issued at 171500Z December.

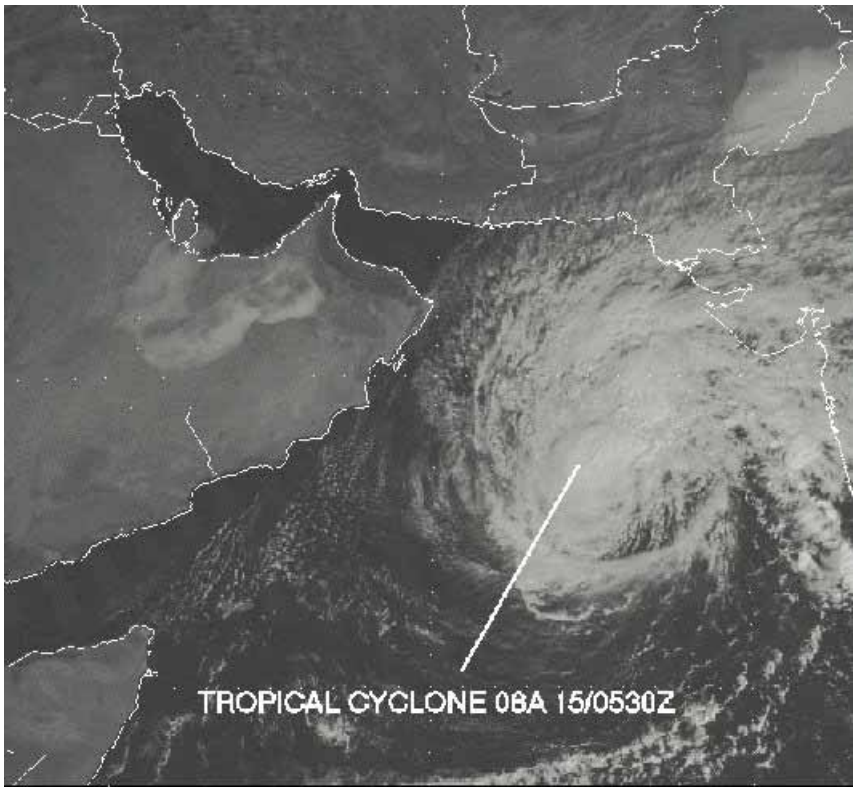
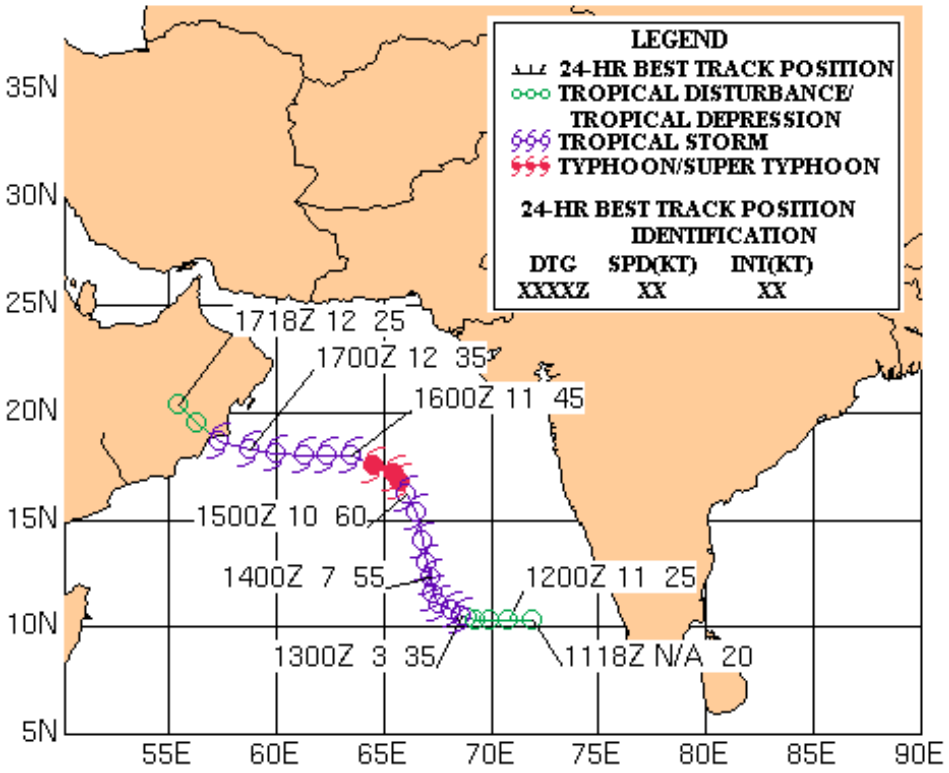


Figure 3-08A-1. Meteosat-5 visible imagery during TC 08A's peak intensity (65 kt).


LEGEND
24-HR BEST TRACK POSITION
TROPICAL DISTURBANCE/
TROPICAL DEPRESSION
TROPICAL STORM
TYPHOON/SUPER TYPHOON
24-HR BEST TRACK POSITION
IDENTIFICATION
DTG SPD(KT) INT(KT)
XXXXZ XX XX
35N
30N
25N
20N
15N
10N
5N
55E
60E
65E
70E
75E
80E
85E
90E
1718Z 12 25
1700Z 12 35
1600Z 11 45
1500Z 10 60
1400Z 7 55
1300Z 3 35
1200Z 11 25
1118Z N/A 20